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Source Assessment: Prioritization of Stationary Air Pollution Sources Model Description

Monsanto Research Corp.

Prepared For
Industrial Environmental Research Lab.

February 1976

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Environmental Protection Technology Series

SOURCE ASSESSMENT:

PRIORITIZATION OF STATIONARY AIR POLLUTION SOURCES—

MODEL DESCRIPTION

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16. ABSTRACT The report describes a prioritization model for the rank-ordering of stationary air pollution sources. The source types were rank-ordered or prioritized by computing a relative environmental impact factor for each source type. A priority listing was developed for each of four categories: combustion, organic materials, inorganic materials, and open sources. The report also describes both the actual application of the model and the types of calculations that were performed depending upon the degree of input aggregation. The report also gives detailed examples of use, as well as results of sensitivity analyses, showing how the prioritization model responds to input changes.

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SOURCE ASSESSMENT:

PRIORITIZATION OF STATIONARY

AIR POLLUTION SOURCES--MODEL DESCRIPTION

by

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Contract No. 68-02-1874
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PREFACE

The Industrial Environmental Research Laboratory (IERL) of EPA has the responsibility for insuring that air pollution control technology is available for stationary sources. If control technology is unavailable, inadequate, uneconomical or socially unacceptable, then development of the needed control techniques is conducted by IERL. Approaches considered include process modifications, feedstock modifications, add-on control devices, and complete process substitution. The scale of control technology programs range from bench to full scale demonstration plants.

The Chemical Processes Branch of IERL has the responsibility for developing control technology for a large number (>500) of operations in the chemical and related industries. As in any technical program the first step is to identify the unsolved problems.

Each of the industries is to be examined in detail to determine if there is sufficient potential environmental risk to justify the development of control technology by IERL. As a first step, Monsanto Research Corporation (MRC) has developed a priority listing of the industries in each of four categories: combustion, organic materials, inorganic materials, and open sources. The purpose and intended use of this listing is that it serve as one of several guides to the selection of those sources for which MRC will

perform detailed source assessments. Source assessment documents will be produced by MRC and used by EPA to make decisions regarding the need for developing additional control technology for each specific source.

Prioritization listings were developed to aid in the selection of specific sources of air emissions for detailed assessment. This report describes the general prioritization model, the manner and form of its implementation, and detailed examples of use.

This prioritization work was initiated under Task XIV, Development of Source Assessment Documents, of Contract 68-02-1320, Quick Reaction Engineering and Technical Services (Multiple Option Services Contract); it was continued and completed under Contract 68-02-1874, Source Assessment.

CONTENTS

Section			Page
I	Introduction		1
II	Model Development and General Structure		3
	A.	Mathematical Structure	6
	B.	Assumptions and Limitations	10
	C.	Application of the Model	13
		1. Derivation of the Ground Level Concentration	13
		2. Data Availability and Computational Form	15
		a. Population Sensitive Calculations	16
		b. Location Sensitive Calculations	17
		c. Detailed Input Calculations	18
		d. Open Source Calculations	18
		3. Uncertainty Levels	19
		4. Prioritization Sensitivity Analyses	20
		5. Priority Listings of the Four Categories: Combustion, Inorganic Materials, Organic Materials, and Open Sources	23
III	Appendixes - Detailed Examples Using Prioritization Model		35
	A.	Use of Model with Common Inputs	36
	B.	Example of Population Sensitive Calculation	40
	C.	Location Sensitive Calculation	50
	D.	Example of Detailed Calculation	58
	E.	Example of Open Sources Calculation	67
IV	References		75

TABLES

Table		Page
1	Effect of Changes in Input Variables on Impact Factor	21
2	Prioritization Listing - Combustion Sources	24
3	Prioritization Listing - Inorganic Sources	25
4	Prioritization Listing - Organic Sources	27
5	Prioritization Listing - Open Sources	32

FIGURES

Figure		Page
1	Acrylonitrile Impact Factor vs. TLV (Organics)	22

SECTION I

INTRODUCTION

This report provides: a general description of the prioritization model and the various factors that it can incorporate; a description of the actual application of the model; a description of the types of calculations that were performed depending upon the degree of input aggregation; the results of sensitivity analyses to show how the prioritization model responds to changes in input; and, detailed examples of use of the model.

The relative rank ordering or prioritization of source types was accomplished by computing a relative environmental impact factor for each source type. A source type is defined as an operation, process, combustion method, or industry that emits common species and has similar emission factors for those species. For example, acrylonitrile manufacturing, coal-fired utility boilers, glass manufacturing, beef cattle feed lots, and open mining of coal represent five different source types. To date, over 600 source types have been identified.

In its implemented form, the prioritization model has taken several aspects. Because of a time constraint and due to the size of the data base, it was necessary in many cases to aggregate the input data. Regardless of the degree of data aggregation, the basic form of the prioritization

model was identical in all cases; only the level of detail in the input was altered.

This model does not attempt, in any fashion, to relate industrial emissions to their effect on public health. Based upon a set of common assumptions, which are clearly identified, the model provides a relative rank ordering (within the framework of these assumptions) of stationary sources of air pollution. A priority listing was developed for each of four categories: combustion, organic materials, inorganic materials, and open sources. Four priority listings were produced since all of the source types could not be grouped into one category. Differences in the nature of the emissions which result from broad dissimilarities in fuel consumption patterns and/or types of products manufactured precluded this.

SECTION II

MODEL DEVELOPMENT AND GENERAL STRUCTURE

The basic proposition of this prioritization model is that emission sources can be ranked, based upon the potential degree of hazard that they impose upon individuals in their environment. This degree of hazard can be expressed in different ways. A traditional method of expressing degree of hazard has been to use the mass of emissions from various source types. Other techniques have used ambient air contributions of a given source type and the resulting degradation of ambient air quality as an indicator of source severity.

The air pollution severity of a given source should in some way be proportional to the degree of potential hazard it imposes upon individuals in its environment. The relative hazard, H, from a specific emission can be defined as being proportional to the ratio of the delivered dose to the toxicity of the material, probability of dose delivery, and number of people who would receive it as follows:

$$H \propto \frac{NP\Psi}{LD_{50}} \qquad (1)$$

where N = number of persons

LD_{50} = lethal dose for 50% of the people exposed

P = probability of dose delivery

Ψ = delivered dose = $B \cdot R \cdot \int \chi(t)dt$

B = average breathing rate

R = lung retention factor

$\chi(t)$ = concentration time history

A relative or potential hazard, H_p, is defined as the ratio of the dose of the pollutant delivered to a population, relative to some potentially hazardous dose. Since LD_{50} data are not available for human beings, another measure of potentially hazardous dosage was used.

The potentially hazardous dose for a given pollutant from a specific point source in a given region is thus defined as follows:

$$\Psi_F = NBR \int_{t_1}^{t_2} TLV(t)\ K\ dt \qquad (2)$$

where Ψ_F = potentially hazardous dose, g

N = population exposed to a specific source, persons

B = average breathing rate, m^3/sec-person

R = lung retention factor for the pollutant of interest (dimensionless factor, $0<R<1$)

K = safety factor = $\left(\frac{40}{168}\right)\left(\frac{1}{100}\right)$

t_1 = start time, sec

t_2 = finish time, sec

TLV®[a] = Threshold Limit Value, g/m^3

The total time of interest, T, is defined as:

$$T = t_2 - t_1 \qquad (3)$$

[a] TLV®, American Conference of Governmental Industrial Hygienists (ACGIH).

Similarly, a hazard potential factor, F, is defined as:

$$F = TLV \cdot K \tag{4}$$

Since TLV is a constant,

$$\Psi_F = N \cdot B \cdot R \cdot T \cdot F \tag{5}$$

The actual pollutant dose delivered, Ψ_A, from a given point source can be calculated as follows:

$$\Psi_A = N \cdot B \cdot R \int_{t_1}^{t_2} \chi\ (t)\ dt \tag{6}$$

where $\chi(t)$ = the actual ground level concentration time history of a pollutant of interest emitted by a specific point source, g/m^3

The value of $\chi(t)$ is very difficult to obtain and was therefore approximated by an average value, $\overline{\chi}$. (Procedures for obtaining $\overline{\chi}$ are discussed in a later section of this report.) The total actual dose delivered for a specific pollutant from a specific source is then:

$$\Psi_A = N \cdot B \cdot R \cdot T \cdot \overline{\chi} \tag{7}$$

Since our measure of potential source hazard, H_P, was defined as the ratio of the two dosages, then:

$$H_P = \frac{\Psi_A}{\Psi_F} = \frac{N \cdot B \cdot R \cdot T \cdot \overline{\chi}}{N \cdot B \cdot R \cdot T \cdot F} \tag{8}$$

or

$$H_P = \frac{\overline{\chi}}{F} \tag{9}$$

A. MATHEMATICAL STRUCTURE

The relative degree of hazard or potential hazard created by the $i^{\underline{th}}$ material in the region around the $j^{\underline{th}}$ source is expressed as the ratio of $\bar{\chi}_{ij}$ to F_i, i.e.,

$$\text{Degree of hazard} = \frac{\bar{\chi}_{ij}}{F_i} \tag{10}$$

In a similar manner, it may be stated that there already exists some ambient level, χ'_{ij}, of the $i^{\underline{th}}$ material at the $j^{\underline{th}}$ source. If there is an ambient air quality standard, S_i, for this emission then a weighting factor, W_{ij}, is defined as follows:

$$W_{ij} = \begin{cases} \dfrac{\chi'_{ij}}{S_i} & \text{when } \dfrac{\chi'_{ij}}{S_i} > 1.0 \\ 1.0 & \text{when } \dfrac{\chi'_{ij}}{S_i} \leq 1.0 \\ 1.0 & \text{when } S_i \text{ is undefined (i.e., for non-criteria pollutants)} \end{cases} \tag{11}$$

For the purpose of this prioritization study, particulates, sulfur oxides, nitrogen oxides, hydrocarbons and carbon monoxide were designated as criteria pollutants. Oxidants are not included in that category because they are not emitted from point sources but instead are formed from nitrogen oxides and hydrocarbons released to the atmosphere.

If the degree of hazard, $\frac{\chi_{ij}}{F_i}$, in equation 10 is multiplied by the population density, P_j, in the region around the $j^{\underline{th}}$ source, a measure of the severity, SV_{ij}, imposed on individuals by the $i^{\underline{th}}$ material at the $j^{\underline{th}}$ source, is obtained:

$$\text{Severity} = SV_{ij} = P_j \frac{\bar{\chi}_{ij}}{F_i} \tag{12}$$

For the $j^{\underline{th}}$ source, the severity vector, SV_j, is defined by:

$$SV_j = \begin{pmatrix} SV_{ij} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ SV_{Nj} \end{pmatrix} = \begin{pmatrix} P_j \frac{\bar{\chi}_{1j}}{F_i} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ P_j \frac{\bar{\chi}_{Nj}}{F_N} \end{pmatrix} \tag{13}$$

where N = number of emitted species. The existing <u>criteria standard or weight vector</u>, W_j, is defined by:

$$W_j = \begin{pmatrix} \frac{\chi'_{1j}}{S_1} \\ \cdot \\ \cdot \\ \cdot \\ \frac{\chi'_{Nj}}{S_N} \end{pmatrix} \tag{14}$$

Ideally, at the $j^{\underline{th}}$ source the severity vector should be zero. Thus, to get a measure of the severity associated with the $j^{\underline{th}}$ source, the Euclidean distance is computed between the calculated severity vector, SV_j, and the zero vector, weighted by the ratio of ambient criteria level to the standard vector, W_j. This distance is also referred to as the length of SV_j and is given by:

$$\text{Length of } SV_j = ||SV_j|| = \left(\sum_{i=1}^{N} SV_{ij}^{\,2} \, W_{ij} \right)^{1/2} \qquad (15)$$

or,

$$||SV_j|| = P_j \left[\sum_{i=1}^{N} \left(\frac{\bar{\chi}_{ij}}{F_i} \right)^2 \frac{\chi'_{ij}}{S_i} \right]^{1/2} \qquad (16)$$

The next step is to assign some numerical value called the impact factor, I_x, to the original source type x in such a way that the impact factors for different source types can be compared and ranked. One possible method is to let the impact factor be the largest of the lengths of the severity vectors associated with the sources j = 1, ..., K_x, i.e.,

$$I_x = \max \left\{ ||SV_j|| \;\middle|\; j = 1, \ldots, K_x \right\} \qquad (17)$$

However, this assigns a high impact factor to a source type that severely pollutes from one point source and has little or no pollution from all other point sources within that source type.

Another possible method of assigning impact factor values is to let I_x be the mean of the lengths of the severity vectors. However, this definition suffers from the varying

number K_x of point sources in the different source types. For example, if $K_x = 10$ for one source type and all severity vectors have unit length, then their mean would be 1, and I_x would have a value of 1. On the other hand, if $K_x = 100$ for another source type and all the severity vectors in this source type are also of unit length, then again the mean value would be 1 and I_x would have the same value as before. However, it is reasonable to assume that the latter source type should have more impact on the environment than the former.

Accordingly, the impact factor, I_x, associated with a given source type x is defined to be the sum of the lengths of the individual severity vectors associated with the point sources within the source type. Thus:

$$I_x = \sum_{j=1}^{K_x} P_j \left[\sum_{i=1}^{N} \left(\frac{\bar{\chi}_{ij}}{F_i} \right)^2 \frac{\chi'_{ij}}{S_i} \right]^{1/2} \qquad (18)$$

where I_x = impact factor, persons/km^2

K_x = number of sources emitting materials associated with source type x

N = number of materials emitted by each source

P_j = population density in the region associated with the $j^{\underline{th}}$ source, persons/km^2

$\bar{\chi}_{ij}$ = calculated maximum ground level concentration of the $i^{\underline{th}}$ material emitted by the $j^{\underline{th}}$ source, g/m^3

F_i = environmental hazard potential factor of the $i^{\underline{th}}$ material, g/m^3

χ'_{ij} = ambient concentration of the $i^{\underline{th}}$ material in the region associated with the $j^{\underline{th}}$ source

S_i = corresponding standard for the $i^{\underline{th}}$ material (used only for criteria emissions, otherwise set equal to one)

B. ASSUMPTIONS AND LIMITATIONS

In this study, the prioritization model was to be computerized, all data handling programs were to be written, and all input data were to be collected and processed within a period of three months. The input data in this case meant descriptions of all stationary air pollution sources in the United States.

Before discussing the actual application of the model, it is appropriate to restate the objectives of the prioritization model, list the elements that it can treat, and indicate the elements that were specifically excluded. (It is not within the scope of this report to provide an exhaustive list of all the things that the model cannot do or was not intended to do. Some objections have been raised regarding various structures and procedures, and these will be addressed in the best way possible without trying to be exhaustive and without trying to anticipate every objection possible.)

The prioritization model was designed to rank order source types in each of four predetermined categories: organic materials, inorganic materials, combustion, and open sources. A concentrated effort was expended to obtain individual category listings for the purpose of providing a basis on which to select areas for future assessment. This means that if in a given priority listing, Source Type A has an impact factor one order of magnitude higher than Source Type B, this does not indicate that any health problems associated with Source Type A are one order of magnitude more severe than those associated with Source Type B. What it does indicate is that within the level of uncertainty in the input data, Source Type A has a potentially greater impact on the environment than Source Type B. The difference in impact factor values cannot be quantitatively interpreted

since this model gives only a relative ranking of source severity.

Some of the factors that the prioritization model is capable of treating in the list of sources developed are shown below :

- a varying number of air pollutants emitted by a given source type
- the hazard potential of emitted particles
- production capacity associated with an emission factor to yield emission rates
- varying heights of emissions
- population density in the region of a source
- existing ambient concentrations of emitted materials
- local meteorological data
- distances from source to receptors (populated areas)
- measured or estimated emission rates
- growth or decline of source types
- measured ambient air concentrations of emitted materials
- atmospheric decay of emitted materials

While the model structure is capable of treating the above factors, not all of them were used in the initial prioritization. Those inputs that were used are identified explicitly in Section II.C.

There are certain clarifying points to be made regarding the model structure and the inclusion of specific terms. The safety factor, $K = [(40/168)(1/100)]$, is used to compensate for the fact that TLV's were established for a five day work week exposure, and that the general population is a higher risk group than healthy workers for which the TLV values were established. Since this factor is constant for

all emitted species, and for all source types, its inclusion into the prioritization model does not affect the ranking. It was kept, however, to preserve computational commonality with other forms of equations that were developed later for describing source severity.

The model does not account for differences in dose/response relationships between pollutant agents; rather, a linear relationship for all materials is assumed. Since the prioritization model and resulting listings are only one of many management tools being used by EPA in the source assessment program, it was not felt that the detailed investigation of dose/response relationships would be beneficial at the time. The model assumes additivity of effects, a technique recommended by ACGIH.

The model does not account for air pollutant persistence, long range transport, and transformation characteristics. Based on the objectives of the prioritization effort and the time constraint, it was thought that the data base used to define the atmospheric transformations and long range transport of a wide variety of pollutants was not sufficiently developed to be usefully included. In a subsequent section of this report, a procedure is described for asking questions about the effect of changes in emitted materials based on the use of sensitivity analysis. Specific examples of this approach include the conversion of all emitted SO_2 to sulfate (using the sulfate TLV), and the conversion of all hydrocarbons to photochemical oxidants (using the photochemical oxidant TLV).

C. APPLICATION OF THE MODEL

1. Derivation of the Ground Level Concentration

Determining the ground level concentration, χ, requires the use of a dispersion model. The simple Gaussian Plume equation for ground level receptors at the plume centerline was used:[1]

$$\chi = \frac{Q}{\pi \sigma_y \sigma_z u} \left\{ \left[\exp -\frac{1}{2} \left(\frac{h}{\sigma_z} \right)^2 \right] \left[\exp -\left(\frac{\lambda x}{u} \right) \right] \right\} \qquad (19)$$

where χ = ground level concentration, g/m^3

σ_y = lateral dispersion coefficient, m

σ_z = vertical dispersion coefficient, m

h = effective emission height, m

Q = emission rate, g/sec

u = wind speed, m/sec

x = distance from source to receptor, m

λ = decay constant, sec^{-1}

The dispersion coefficients are power law functions of downwind distance and atmospheric stability:[2]

$$\sigma_y = ax^{0.9031} \qquad (20)$$

$$\sigma_z = bx^c + d \qquad (21)$$

---

[1]Turner, D. B. Workbook of Atmospheric Dispersion Estimates. Publication No. 191482, May 1970.

[2]Eimutis, E. C., and M. G. Konicek. Derivations of Continuous Functions for the Lateral and Vertical Atmospheric Dispersion Coefficients. Atmospheric Environment, 6:859-863, 1972.

Coefficients a, b, c, and d were derived for the various stability categories.[2]

It was noted that compiling data on distances from sources to receptors would not prove feasible. Hence, there remained atmospheric stability, wind speed, and decay constants as required inputs. After a review of the prioritization objectives and projected use of the prioritization listings, it was decided that decay constants would not be used, and that constant average values would be used as input for wind speed and atmospheric stability.

Since emission height data were compiled, the maximum ground level concentration, χ_{max}, was computed from the following:[3]

$$\chi_{max} = \frac{2Q\sigma_z}{\pi e u h^2 \sigma_y} \qquad (22)$$

where Q = emission rate, g/sec
e = base e = 2.72
u = wind speed, m/sec
h = emission height, m

For neutral or slightly unstable conditions, $\sigma_z \cong \sigma_y$,[3] and:

$$\frac{\sigma_z}{\sigma_y} \cong 1 \qquad (23)$$

The national average wind speed was used as a constant input (approximately 10 mph or 4.5 m/sec). The average

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[3]Slade, H. S. (ed.). Meteorology and Atomic Energy. Publication TID 24190, July 1968.

concentration, $\bar{\chi}$, is a function of sampling time, t, and can be related to the maximum concentration, χ_{max}, by the following:[1]

$$\bar{\chi} \propto \chi_{max}\, t^{-p} \qquad (24)$$

where $0.17 \lesssim p \lesssim 0.2$

Since a relative rank ordering was being performed, the choice of constants did not affect the ordering and χ_{max} was used directly for $\bar{\chi}$.

The buoyancy and momentum data needed to estimate plume rise could not be compiled within the project time frame. The emission height thus corresponds to the physical and not the effective emission height. Fall-out, washout, surface adsorption and vegetative absorption were not included in the implemented model.

2. Data Availability and Computational Form

Data availability can be summarized in two categories: little or no data available for a given source type; or, thousands of pages of computerized printout of point source information. It was quickly evident that, for the latter case, some form of input data aggregation would have to be performed.

It should be noted that the basic model structure was not changed; only the level of detail was altered for those source types with emission points numbering in the thousands and, in some cases, in the hundreds of thousands. Four types of calculations and procedures were implemented:

- Population sensitive calculations - Examples include industrial boilers, asphalt plants, ready-mix concrete plants, etc. These industries were assumed to be located, preferentially, in areas of higher population or distributed according to population fraction.

- Location sensitive calculations - Examples include cotton gins, mining operations, etc. These source types are located only in certain areas of the country.
- Detailed source calculations - These are the source types with only a small (less than 10) number of plants. An example is acrylonitrile manufacturing plants. In this case, the prioritization model in its detailed form was used. Each plant was included as a separate point source.
- Open source calculations - These source types were categorized as population sensitive, area sensitive, or location sensitive. Separate programs were written to deal with the differing inputs which the open sources calculation required.

a. Population Sensitive Calculations

For population sensitive calculations, the population fraction of each state was taken from the 1970 Census. The national yearly capacity or fuel consumption for a given source type was then distributed as follows:

$$PF_j = \frac{P_j}{\sum_{j=1}^{50} P_j} \tag{25}$$

where PF_j = population fraction in the j^{th} state

P_j = population of the j^{th} state

Then, for the i^{th} pollutant,

$$Q_{ij} = \frac{1}{f} (K_f)(E_i)(PF_j)(CAP) \qquad (26)$$

where Q_{ij} = emission rate, g/sec

f = frequency of operation, days/365 days

E_i = emission factor, lbs of i^{th} emission/tons of product or fuel

CAP = national yearly capacity or fuel consumption, tons

K_f = conversion factor (lbs/year to g/sec)

The frequency factor was included since many industries and operations exist that are intermittent or seasonal. If a process operates for 100 days out of a year, then the emissions rate is 3.65 times higher than it would be if one had assumed continuous yearly operation.

Ambient air averages for the criteria pollutants were used for each state and the model was exercised as previously described. A full listing of the state data base is presented later in Tables A-1 and A-2 of Appendix A.

b. Location Sensitive Calculations

For some source types, capacity information was available on a state by state basis. For example, for coal-fired steam electric utilities, data are published on fuel consumption on a state basis. Knowing the capacity and its distribution across the states for each emission, the emission rate is calculated as follows:

$$Q_{ij} = \frac{1}{f} (K_f)(E_i)(CAP_j) \qquad (27)$$

The impact factor is then calculated in the usual fashion and summed over K_x states.

c. Detailed Input Calculations

Detailed input calculations were segregated by county for population densities. Since the county ambient air summaries were not available, corresponding state values were used. Individual plant capacities were used to calculate the emission rates and the summation extended over the number of plants in a given source type.

d. Open Source Calculations

Open source calculations were further divided into three types: (1) population sensitive, (2) area sensitive, and (3) location sensitive. Population sensitive calculations were performed as previously described. Area sensitive calculations were performed using:

$$AF_j = \frac{A_j}{\sum_{j=1}^{50} A_j} \tag{28}$$

where AF_j = area fraction of the $j^{\underline{th}}$ region or state

A_j = area of the $j^{\underline{th}}$ region or state, mi^2

Then,

$$Q_j = \frac{1}{f} (CAP)(E_j)(AF_j)(K_f) \tag{29}$$

and the national capacity is apportioned according to area. Open source location sensitive calculations were performed as previously described.

These descriptions of the various calculation methods have been brief and are meant to serve as an introduction. Detailed examples of their use are included in the Appendix.

3. Uncertainty Levels

There is a level of uncertainty associated with each impact factor. While that level cannot be quantified, it can be assumed to vary as a function of the quality of available information on a specific source type. Using this rationale, the priority index uncertainty levels were defined as follows:

Level	Meaning
A	Adequate data of reasonable accuracy
B	Partly estimated data of indeterminate accuracy
C	Totally estimated data of indeterminate accuracy
D	Missing data on known emissions of toxic substances

• Example of Level A - Adequate data of reasonable accuracy are available for the gas-fired steam electric utilities. Emissions are known and emission factors are published for this industry.

• Example of Level B - Partly estimated data are available for oil-fired industrial/commercial boilers. These data represent best engineering estimates.

• Example of Level C - Totally estimated data are the type available for the emissions from all types of structural fires.

• Example of Level D - If it is known that a source is emitting asbestos, mercury, beryllium, cadmium, POM's, benzenoid aromatics, or other suspected carcinogens and yet no quantitative data for such emissions are available, then that source type has an uncertainty level of D. Coal refuse piles - open burning is an example of this level of uncertainty.

The above defined uncertainty levels are subjective. They were assigned by the individual responsible for generating data for a specific source type. Even with the lowest uncertainty level, Level A, attempts to quantify the uncertainty would present a formidable task. However, sensitivity analyses were performed on the prioritization model in order to observe its response to changes in the inputs. These results are discussed in the following section.

4. Prioritization Sensitivity Analyses

The sensitivity, ΔI_x, of the impact factor, I_x, to changes in various inputs was defined as:

$$\Delta I_x = 100\left(\frac{I_{x(new)} - I_{x(base)}}{I_{x(base)}}\right) \qquad (30)$$

where $I_{x(base)}$ = impact factor based on original input

$I_{x(new)}$ = impact factor based on revised input

Coal-fired steam electric utilities were selected as an example source type for this sensitivity analysis. In the calculation, one input variable at a time is either increased or decreased by a constant factor and the percent ΔI_x is noted. This process was performed on several of the input variables. The following table summarizes the variables altered (Z), and the corresponding percent changes in the impact factor.

Table 1. EFFECT OF CHANGES IN INPUT VARIABLES ON IMPACT FACTOR

Input variable (Z)	ΔI_x (%) when input variable is 1.5 Z	ΔI_x (%) when input variable is 0.5 Z
Frequency	-33.3	100.0
Wind speed	-33.3	100.0
TLV	-33.3	100.0
Criteria standard	-18.4	41.4
Emission height	-55.6	300.0
Emission factor	50.0	-50.0
Criteria concentration	22.5	-29.3
Capacity	50.0	-50.0
Population density	50.0	-50.0

In another test of sensitivity, the effect of pollutant transformation was investigated. The specific example was the conversion to sulfate of all SO_2 emitted by a coal-fired electric utility. Using TLV's as indicators of sensitivity, the following results were computed:

	TLV, g/m^3	I_x (normalized)
SO_2	0.014	100
Sulfate	0.0042	247

In this case, a 70% decrease in TLV value produced a 147% increase in the impact factor.

In another instance, questions were raised concerning SO_2 emission factors. The impact factors for coal-fired utilities were computed with a base-line emission factor and with a factor three times higher (i.e., 200% increase). The impact factor showed a corresponding 190% increase.

Another example of sensitivity was shown using acrylonitrile manufacturing as an example. By varying the TLV's of three emissions (acrylonitrile, propane, and propylene) the results shown in Figure 1 were obtained.

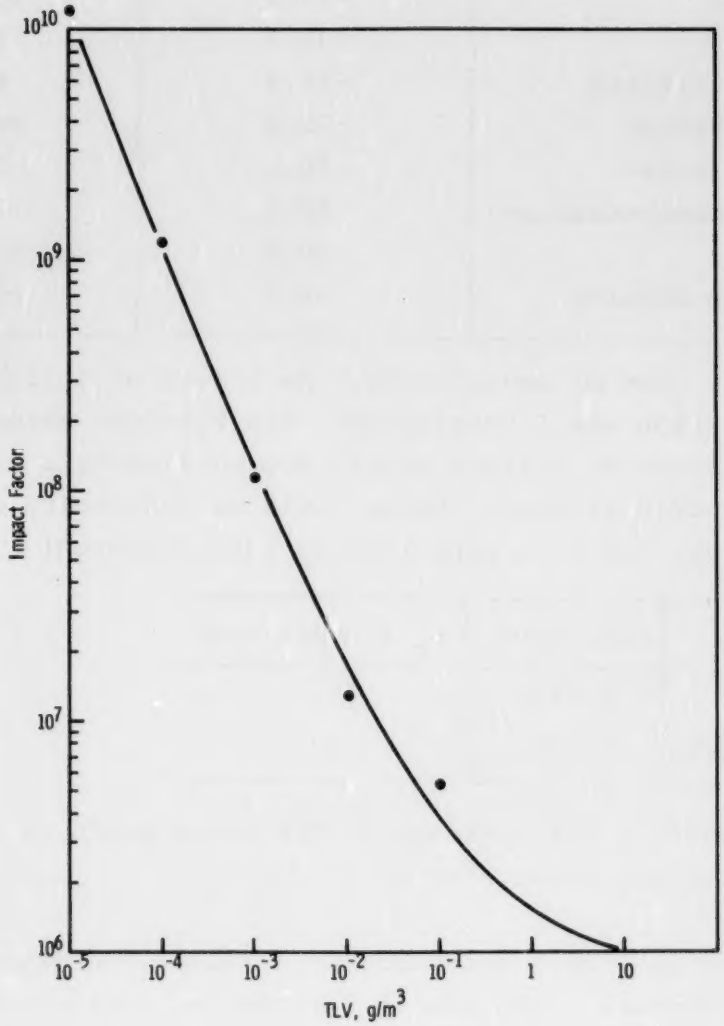

Figure 1. Acrylonitrile impact factor vs. TLV (organics)

5. Priority Listings of the Four Categories: Combustion, Inorganic Materials, Organic Materials and Open Sources

Several data management routines were written in FORTRAN IV and these were interfaced with impact factor calculation routines, sorting, file manipulation and reporting programs. Priority listings were produced for the combustion, inorganic materials, organic materials, and open sources categories and these are presented in Tables 2 through 5. The column labeled "UL" refers to the uncertainty level as described earlier in Section II.C.3, and the column labeled "CALC" refers to the type of calculation used as described earlier in Section II.C.2.

CALC	Meaning
1	Population sensitive calculation
2	Location sensitive calculation
3	Detailed input calculation
4	Open source calculation

Table 2. PRIORITIZATION LISTING - COMBUSTION SOURCES

COMBUSTION SOURCES

SOURCE TYPE	IMPACT FACTOR	UL	CALC
COAL REFUSE PILES, OUTCROPS AND ABANDONED MINES	900,000,000	D	2
PRESCRIBED BURNING	200,000,000	C	2
AGRICULTURAL OPEN BURNING	200,000,000	B	2
FUEL BURNING ENGINES - RECIPROCATING	100,000,000	C	1
OIL FIRED INDUSTRIAL/COMMERCIAL BOILERS	60,000,000	B	2
FUEL BURNING ENGINES - TURBINE	50,000,000	C	1
COAL FIRED RESIDENTIAL SPACE HEATING	30,000,000	B	2
OIL FIRED RESIDENTIAL SPACE HEATING	10,000,000	B	2
CHARCOAL MANUFACTURE	6,000,000	C	1
GAS FIRED RESIDENTIAL SPACE HEATING	5,000,000	B	2
SWIMMING POOL HEATING	4,000,000	C	2
INDUSTRIAL/COMMERCIAL SPACE HEATING	4,000,000	D	1
OIL-FIRED STEAM ELECTRIC UTILITIES	3,000,000	B	2
COAL-FIRED STEAM ELECTRIC UTILITIES	2,000,000	B	2
GAS FIRED AIR CONDITIONING	2,000,000	C	2
GAS FIRED INDUSTRIAL/COMMERCIAL BOILERS	2,000,000	B	2
RESIDENTIAL INCINERATION	1,000,000	C	1
GAS FIRED LAUNDRY DRYING	1,000,000	C	2
ORCHARD HEATING	1,000,000	D	2
GAS FIRED RESIDENTIAL WATER HEATING	900,000	B	2
WOOD WASTE INCINERATION	900,000	C	2
COAL-FIRED INDUSTRIAL/COMMERCIAL BOILERS	900,000	B	2
WOOD FIRED RESIDENTIAL SPACE HEATING	500,000	C	2
INCINERATION OF "TYPE 1" WASTE	400,000	D	1
REFUSE INCINERATION/PYROLYSIS - STEAM GENERATION	300,000	B	3
INCINERATION OF "TYPE 6" WASTE	200,000	D	1
OPEN BURNING OF INDUSTRIAL WASTE	200,000	D	1
MUNICIPAL INCINERATION	100,000	B	1
MUNICIPAL REFUSE/COAL FIRED UTILITIES	100,000	D	3
INCINERATION OF "TYPE 0" WASTE	90,000	D	1
JET ENGINE TESTING	70,000	D	1
GAS-FIRED STEAM ELECTRIC UTILITIES	60,000	A	2
COVERED WIRE INCINERATION	60,000	D	1
AUTOBODY INCINERATION	30,000	B	1
INCINERATION OF "TYPE 2" WASTE	30,000	D	1
OPEN BURNING OF WOOD WASTE	20,000	C	2
INCINERATION OF "TYPE 4" WASTE	20,000	C	1
OPEN BURNING OF JET FUEL	10,000	D	1
INCINERATION OF "TYPE 3" WASTE	10,000	D	1
INCINERATION OF "TYPE 5" WASTE	9,000	D	1
DRUM INCINERATION	9,000	D	1
SEWAGE SLUDGE INCINERATION	9,000	C	1
ELECTRICAL EQUIPMENT WINDING RECLAMATION	9,000	D	1
OPEN PIT INCINERATION	5,000	D	1
HOSPITAL WASTE INCINERATION	3,000	D	1
OPEN BURNING OF RAIL CARS	2,000	C	3
EXPLOSIVES BURNING	2,000	D	2
BRAKE SHOE DEBONDING	100	D	1
LAND CLEARING - OPEN BURNING			1
OPEN BURNING OF AUTO BODIES			1
ON SITE BURNING - OPEN BURNING			1
MUNICIPAL DUMPS - OPEN BURNING			1
ROCKET ENGINE TESTING			1
STRUCTURAL FIRES			1
NATURAL FIRES			1

Table 3. PRIORITIZATION LISTING - INORGANIC SOURCES

INORGANIC SOURCES

SOURCE TYPE	IMPACT FACTOR	UL	CALC
COTTON GINS	200,000,000	B	2
PRODUCTION OF LEAD STORAGE BATTERIES	30,000,000	C	2
PIG IRON PRODUCTION	20,000,000	C	2
COKE MANUFACTURE	20,000,000	D	2
BRICK KILNS AND DRIERS	2,000,000	C	2
IRON FOUNDRIES	2,000,000	C	2
ASBESTOS PRODUCTS	2,000,000	B	2
TOBACCO	1,000,000	C	2
PRIMARY ZINC SMELTING	1,000,000	C	2
SECONDARY LEAD SMELTING AND REFINING	1,000,000	D	1
STEEL PRODUCTION	900,000	C	2
LEAD CARBONATE AND SULFATE - WHITE LEAD	800,000	D	3
CADMIUM PIGMENTS - CADMIUM SULFIDE, SULFOSELENIDE, LITHOPONE	800,000	C	3
AMMONIA	800,000	A	2
LEAD OXIDE - RED LEAD AND LITHARGE - PIGMENTS ONLY	700,000	D	3
TITANIUM DIOXIDE - PIGMENT	500,000	B	3
COAL CLEANING PLANTS - THERMAL DRYING	500,000		2
SECONDARY ZINC SMELTING	400,000	C	1
COBALT COMPOUNDS - ACETATE, CARBONATE, HALIDES, ETC.	400,000	C	3
GLASS INDUSTRY	400,000	A	2
SILVER COMPOUNDS - NO3, DIFLUORIDE, FLUOROBORATE, SO4	300,000	D	3
PRIMARY ALUMINUM PRODUCTION	300,000	C	2
SULFURIC ACID	300,000	B	2
PRIMARY LEAD SMELTING AND REFINING	300,000	C	2
ZINC CHLORIDE - 50 DEGREE BAUME'	200,000	D	3
VITREOUS KAOLIN PRODUCTS	200,000	C	2
ELECTROLYTIC PRODUCTION OF CHLORINE	200,000	B	2
FERROALLOY PRODUCTION	200,000	C	2
ZINC OXIDE - PIGMENT	200,000	B	2
REFRACTORIES	100,000	B	2
LIME KILNS	100,000	A	2
AMMONIUM NITRATE	100,000	B	2
SECONDARY ALUMINUM PRODUCTION	100,000	D	1
FERTILIZERS - BULK BLENDING PLANTS	100,000	C	2
COPPER SULFATE - PENTAHYDRATE	100,000	C	3
PHOSPHORIC ACID - WET PROCESS	90,000	B	2
STEEL FOUNDRIES	90,000	D	2
CALCIUM CARBIDE	90,000	B	3
POTASSIUM HYDROXIDE	90,000	C	3
BRASS AND BRONZE INGOT PRODUCTION	80,000	C	1
MERCURY COMPOUNDS - HALIDES, NITRATES, OXIDES, ETC.	80,000	D	3
CEMENT	80,000	B	2
AMMONIUM SULFATE	70,000	C	3
COAL CLEANING PLANTS - PNEUMATIC	60,000		2
BORIC ACID AND BORAX - SODIUM TETRABORATE	50,000	B	3
SODIUM CHROMATE AND SODIUM DICHROMATE	50,000	C	3
SODIUM TRIPOLYPHOSPHATE	40,000	C	3
MINERAL WOOL	40,000	B	2
PHOSPHATE ROCK - DRYING, GRINDING, CALCINING	40,000	B	2
TRIPLE SUPERPHOSPHATES	40,000	B	3
ALUMINUM OXIDE - ALUMINA	40,000	C	3
CHLOROSULFONIC ACID - INORGANIC ACIDS	30,000	D	3
NICKEL SULFATE	30,000	C	3
AMMONIUM PHOSPHATES	30,000	B	2
LEAD ARSENATE - ACID ORTHO-ARSENATE - BASIC ORTHO-ARSENATE	30,000	D	3
NITRIC ACID	20,000	A	2
CHROMIC ACID	20,000	C	3
ZINC GALVANIZING OPERATIONS	20,000	B	2
CALCIUM CHLORIDE	20,000	C	3
SUPERPHOSPHATE - NORMAL	20,000	B	2
PHOSPHORIC ACID - THERMAL PROCESS	20,000	A	2
PHOSPHORUS PENTASULFIDE	20,000		3
MANGANESE SULFATE	20,000		3
POTASSIUM BICHROMATE AND POTASSIUM CHROMATE	20,000	C	3
SODIUM SILICOFLUORIDE	20,000	C	3
PHOSPHORUS TRICHLORIDE	10,000		3
IRON OXIDE - PIGMENTS	10,000	C	2
LEAD CHROMATE - CHROME YELLOW AND ORANGE	10,000	D	3
PRIMARY COPPER SMELTING	10,000	C	2
HYDROFLUORIC ACID	10,000	B	3
SODIUM CARBONATE - SYNTHETIC	10,000	C	3
PHOSPHORUS - ELEMENTAL	10,000	B	3
LEAD COMPOUNDS - HALIDES, HYDROXIDES, DIOXIDE, NITRATE, ETC.	10,000	D	3
FLUORINE	10,000	D	3
GYPSUM	9,000	B	2
PHOSPHATE ROCK DEFLUORINATION	9,000	B	3
ALUMINUM FLUORIDE	9,000	C	2

Table 3 (continued). PRIORITIZATION LISTING - INORGANIC SOURCES

SODIUM SILICATES	9,000		2
POTASSIUM PERMANGANATE AND MANGANESE DIOXIDE	9,000	C	3
FERTILIZER MIXING - AMMONIATION - GRANULATION PLANTS	7,000	B	2
CHROMIUM OXIDE - INORGANIC PIGMENT	7,000	C	3
ANTIMONY OXIDE	7,000	D	3
ZINC CHROMATE - PIGMENT	7,000	D	3
BARIUM SULFATE - PIGMENT	6,000	C	3
CALCIUM PHOSPHATE	6,000		3
SODIUM SULFIDE	6,000	C	3
TIN COMPOUNDS - HALIDES, OXIDES, SULFATES, OTHERS	6,000	C	3
POTASH - POTASSIUM SALTS	5,000	C	3
ARSENIC TRIOXIDE	5,000	D	3
FERTILIZER MIXING - LIQUID MIX PLANTS	5,000	B	2
ALUMINUM HYDROXIDE	5,000	C	2
HYDROCHLORIC ACID	5,000	B	2
PERLITE MANUFACTURING	4,000	C	2
ABRASIVE PRODUCTS	4,000	C	2
SODIUM FLUORIDE	4,000	C	3
HYDRAZINE	4,000	C	3
BARIUM CARBONATE	3,000	C	3
HYDROGEN CYANIDE	3,000	B	3
CALCIUM CARBONATE	3,000	C	3
SODIUM SULFATE - NATURAL PROCESS ONLY	2,000	C	3
ALUMINUM SULFATE	2,000	C	2
SODIUM ARSENITE	2,000	D	2
EXFOLIATED VERMICULITE	2,000	C	2
SODIUM HYDROSULFIDE - SODIUM BISULFIDE OR SULFHYDRATE	1,000	C	3
NICKEL COMPOUNDS - EXCEPT NICKEL SULFATE	1,000	C	2
ALUMINUM CHLORIDE - ANHYDROUS	1,000	C	2
MAGNESIUM COMPOUNDS - CARBONATE, CHLORIDE, OXIDE & HYDROXIDE	1,000	C	2
SODIUM THIOSULFATE - SODIUM HYPOSULFITE	1,000	C	3
SODIUM SULFITE	800	C	3
IRON CHLORIDE - FERRIC	800	C	2
SODIUM CHLORATE	700	C	3
BERYLLIUM COMPOUNDS	500	D	3
CALCIUM ARSENATE	400	D	3
BROMINE	400	C	3
SODIUM HYDROSULFITE	400	C	3
SODIUM CARBONATE - NATURAL	400	C	3
CONVERSION OF CRUDE IODINE TO RESUBLIMED AND IODINE PRODUCTS	300	C	2
POTASSIUM SULFATE	300	C	3
MISCELLANEOUS SODIUM COMPOUNDS	100	C	2
CHROMIUM COMPOUNDS - ACETATE, BORIDES, HALIDES, ETC.	100	D	2
SODIUM NITRITE	70	C	3
SULFUR MONOCHLORIDE AND DICHLORIDE	50	C	3
LITHIUM SALTS - LITHIUM CARBONATE AND LITHIUM HYDROXIDE	7	C	3
CRUDE IODINE - DOMESTIC PRODUCTION	6	C	3
PHOSPHORUS OXYCHLORIDE	2	C	3
SECONDARY MAGNESIUM SMELTING	2	C	2

Table 4. PRIORITIZATION LISTING - ORGANIC SOURCES

ORGANIC SOURCES

SOURCE TYPE	IMPACT FACTOR	UL	CALC
SOLVENT EVAPORATION - DEGREASING	100,000,000,000	B	1
FABRIC SCOURING	1,000,000,000	D	2
PETROLEUM REFINING - FUGITIVE EMISSIONS	300,000,000	C	2
TRICHLOROETHYLENE - FROM ETHYLENE	200,000,000	B	3
PETROLEUM REFINING - WASTE WATER PLANT	80,000,000	C	2
PETROLEUM EXTRACTION	50,000,000	B	2
NATURAL GAS DISTRIBUTION	30,000,000	B	2
GASOLINE DISTRIBUTION - AUTOMOBILE TANK LOADING	20,000,000	A	1
SURFACE COATING - SHEET, STRIP AND COIL COATING	20,000,000	C	2
PETROLEUM REFINING - BLENDING AND STORAGE	10,000,000	C	2
SURFACE COATING - PAPER AND PAPERBOARD COATING	10,000,000	C	2
POLYVINYL CHLORIDE	10,000,000	A	2
NATURAL GAS EXTRACTION	10,000,000	B	2
SOLVENT EVAPORATION - RUBBER AND PLASTIC PROCESSING	8,000,000	C	2
SOLVENT EVAPORATION - DRYCLEANING	7,000,000	C	1
SURFACE COATING - FABRIC TREATMENT	6,000,000	C	2
SOLVENT EVAPORATION - PRINTING AND PUBLISHING	3,000,000	C	1
ASPHALT PAVING - HOT MIX	3,000,000	B	1
SOLVENT EVAPORATION - SURFACE COATING - AUTO PAINTING	1,000,000	C	2
ASPHALT ROOFING	1,000,000	C	1
PETROLEUM REFINING - CATALYTIC CRACKING	800,000	B	2
SURFACE COATING - MAJOR APPLIANCE FINISHING	700,000	C	2
ETHYLENE DICHLORIDE - OXYCHLORINATION	700,000	B	3
ETHYLENE DICHLORIDE - ETHYLENE CHLORINATION	700,000	B	3
VARNISH MANUFACTURERS	600,000	D	2
PHTHALIC ANHYDRIDE - O-XYLENE	400,000	B	3
GASOLINE DISTRIBUTION - SERVICE STATION TANKS	300,000	A	1
ETHYLENE-PROPYLENE RUBBER	300,000	C	3
ACRYLIC ACID	300,000	B	3
ARTIFICIAL RIPENING OF FRUITS AND VEGETABLES	300,000	D	1
DEEP FRYING	300,000	D	1
NEOPRENE	300,000	A	3
MALT BEVERAGE PRODUCTION	300,000	C	2
PETROLEUM REFINING - VACUUM DISTILLATION	200,000	B	2
FRUIT AND VEGETABLE CANNING	200,000	C	2
VINYL CHLORIDE - ETHYLENE DICHLORIDE	200,000	B	3
ETHYL CHLORIDE	200,000	B	3
SURFACE COATING - INDUSTRIAL MACHINERY FINISHING	200,000	C	2
TRICHLOROETHYLENE - FROM ACETYLENE	200,000	B	3
SURFACE COATING - METAL FURNITURE FINISHING	200,000	C	2
PETROLEUM REFINING - SULFUR PLANT	200,000	B	2
PETROLEUM REFINING - ASPHALT PLANT	200,000	B	2
PRINTING INK	200,000	D	2
2-ETHYL-1-HEXANOL	200,000	B	3
DIMETHYL TEREPHTHALATE	200,000	C	3
SURFACE COATING - WOOD FURNITURE FINISHING	100,000	C	2
ACETONE - FROM CUMENE	100,000	C	3
WOOD PROCESSING - KRAFT OR SULFATE PROCESS	100,000	B	2
SURFACE COATING - SMALL APPLIANCE FINISHING	100,000	C	2
PERCHLOROETHYLENE - CHLORINATION OF PROPANE	100,000	B	3
CARBON TETRACHLORIDE - CHLORINATION OF PROPANE	100,000	B	3
POLYETHYLENE RESIN - HIGH DENSITY	100,000	B	3
PETROLEUM REFINING - CRUDE DISTILLATION	100,000	B	2
POLYSTYRENE RESIN	100,000	C	2
CRESOL - SYNTHETIC	100,000	B	3
POLYETHYLENE RESIN - LOW DENSITY	100,000	B	3
POLYMETHYLENE POLYPHENYL ISOCYANATE	100,000	C	3
CARBON BLACK - FURNACE	90,000	B	2
FRUIT AND VEGETABLE FREEZING	80,000	C	2
METHYL METHACRYLATE	80,000	B	3
CYCLOHEXANONE	70,000	B	3
ASPHALT PAVING - DRYER DRUM PROCESS	70,000	D	1
ADIPONITRILE	60,000	C	3
METHYL ISOBUTYL KETONE	60,000	C	3
ACETIC ANHYDRIDE	60,000	B	3
PLYWOOD AND VENEER DRYING	60,000	C	2
PHENYLMERCURY OLEATE	50,000	D	3
PHENOL - CUMENE PROCESS	50,000	B	3
FORMALDEHYDE	50,000	C	2
GLYCERIN TRIPOLYOXYPROPYLENE ETHER	50,000	C	3
ACRYLONITRILE	40,000	B	3
MALEIC ANHYDRIDE FROM BENZENE	40,000	B	3
PHTHALIC ANHYDRIDE - NAPHTHALENE	40,000	B	3
GASOLINE DISTRIBUTION - TERMINAL LOADING AND STORAGE	40,000	A	1
VINYL ACETATE - FROM ETHYLENE	30,000	B	3
FUMARIC ACID	30,000	C	3

Table 4 (continued). PRIORITIZATION LISTING - ORGANIC SOURCES

SURFACE COATING - FARM MACHINERY FINISHING	30,000	C	2
SURFACE COATING - COMMERCIAL MACHINERY FINISHING	30,000	C	2
VINYL CHLORIDE - ACETYLENE	30,000	B	3
GLYCERIN - ALLYL ALCOHOL	30,000	C	3
NATURAL GAS PROCESSING	30,000	B	2
PAINT MANUFACTURING	20,000	D	2
POLYESTER RESINS - UNSATURATED	20,000	C	2
WOOD PROCESSING - SULFITE PROCESS	20,000	B	2
DICHLORODIFLUOROMETHANE	20,000	C	3
HEXAMETHYLENETETRAMINE	20,000	C	3
KELTHANE	10,000	D	3
GLYCERIN - ACROLEIN	10,000	C	3
METHANOL	10,000	C	3
COTTONSEED OIL MILLING	10,000	C	2
SOAP AND DETERGENTS	10,000	C	2
POLYCHLORINATED BIPHENYLS	10,000	C	3
CARBON TETRACHLORIDE - METHANE	10,000	B	3
AMINO RESINS	10,000	C	2
SUGAR PROCESSING	10,000	D	2
ACETIC ACID	9,000	B	3
O-XYLENE	8,000	C	3
P-XYLENE	8,000	B	2
PETROLEUM REFINING - FLARES	8,000	B	2
NYLON 66	8,000	B	2
DODECYLBENZENE SULFONIC ACID - SODIUM SALT	8,000	C	2
VEGETABLE OIL MILLING	8,000	C	2
GLYCERIN - ALLYL CHLORIDE	7,000	C	3
N-BUTYL ALCOHOL	7,000	C	3
COFFEE ROASTING	7,000	B	2
MALATHION	7,000	D	3
METHYL PARATHION	6,000	C	3
ACETALDEHYDE - OXIDATION OF ETHANOL	6,000	C	3
WOOD PROCESSING - NEUTRAL SULFITE SEMI-CHEMICAL	6,000	B	2
POLYVINYLVINYLIDENE CHLORIDE	5,000	D	3
LEATHER	5,000	D	1
ADIPIC ACID	5,000	B	3
PETROLEUM REFINING - ETHYLENE PLANT	5,000	C	2
CUMENE	5,000	C	2
STYRENE	4,000	B	3
CHLOROSULFONIC ACID	4,000	C	3
DODECYLBENZENE - HARD	4,000	C	3
DDT	4,000	C	3
PENTAERYTHRITOL	4,000	C	3
ISOCYANATES	4,000	B	3
POLYACRYLONITRILE - POLYMERIZATION SOLUTION	4,000	C	3
CYCLOHEXANE	4,000	C	3
ACETYLENE	4,000	C	3
EPICHLOROHYDRIN	4,000	B	3
WET CORN MILLING	4,000	D	2
DODECYLBENZENE SULFONIC ACID	4,000	C	2
ACETONE CYANOHYDRIN	3,000	C	3
POLYURETHANE ELASTOMER	3,000	C	2
ACETIC ACID - FROM METHANOL	3,000	C	3
METHYLENE CHLORIDE - CHLORINATION OF METHANE	3,000	B	3
ACETYL CHLORIDE	3,000	D	3
POLYURETHANE SURFACE COATING RESINS	3,000	D	2
CRESYLIC ACID	3,000	B	2
PETROLEUM REFINING - CATALYTIC REFORMING	3,000	B	2
NYLON 6	3,000	B	2
MIXED OLEFINIC PRODUCT	3,000	C	3
MIXED LINEAR ALCOHOL	3,000	C	2
PETROLEUM REFINING - CATALYTIC HYDROREFINING (HDS)	3,000	B	2
UREA	3,000	C	2
FORMIC ACID	3,000	C	3
LINEAR ALKYLBENZENE	3,000	C	3
HEPTACHLOR	3,000	C	3
ENDRIN	3,000	D	3
WASTE SOLVENT PROCESSING	2,000	D	1
NONYLPHENOL	2,000	C	3
DODECYLBENZENE SULFONIC ACID - CALCIUM SALT	2,000	C	3
MEAT SMOKEHOUSES	2,000	D	2
DISTILLED LIQUOR	2,000	C	1
TOLUENE DIISOCYANATE	2,000	C	3
TEREPHTHALIC ACID	2,000	B	3
O-DICHLOROBENZENE	2,000	B	3
HYDROQUINONE	2,000	C	3
CARBON TETRACHLORIDE - CARBON DISULFIDE	2,000	B	3
ISOPRENE - 2-METHYL-1,3-BUTADIENE	2,000	C	3
HEPTENE	2,000	C	3
DI-2-ETHYLHEXYL PHTHALATE	2,000	C	2
ETHYLENE DIBROMIDE	2,000	C	3

Table 4 (continued). PRIORITIZATION LISTING - ORGANIC SOURCES

NITROBENZENE	2,000	B	3
NAPHTHALENE - COAL TAR	2,000	C	2
N-PARAFFIN CHLORIDE	2,000	C	3
ENDOSULFAN - THIODAN	2,000	D	3
PROPYLENE OXIDE - CHLOROHYDRIN PROCESS	2,000	B	3
ALKYD RESINS	1,000	C	2
POLYAMIDE RESINS	1,000	C	2
ETHYLENE OXIDE	1,000	B	2
CELLULOSE ACETATE	1,000	C	3
POLYURETHANE FIBERS	1,000	D	3
ALDRIN	1,000	D	3
EPOXY RESINS - UNMODIFIED	1,000	C	3
S-BUTYL ALCOHOL	1,000	C	3
RAYON - SEMI SYNTHETIC VISCOSE RAYON	1,000	B	3
TOLUENE SULFONATE - HYDROTROPE	1,000	C	3
ETHYLENE - PROPYLENE TERPOLYMER	1,000	B	3
ISOPHTHALIC ACID	1,000	B	3
OXALIC ACID	1,000	B	3
1,1,1-TRICHLOROETHANE	1,000	B	3
FOOD PREPARATION	1,000	C	2
OXO PROCESS	1,000	B	2
BENZYL CHLORIDE	1,000	C	3
CARBON DISULFIDE	1,000	B	3
CHLOROACETIC ACID	900	C	3
SORBITOL	900	C	3
DIISODECYL PHTHALATE	900	C	3
AMMONIUM OXALATE	900	D	3
CHLOROPHENOL	800	C	3
CHLOROFORM	800	B	3
OXO MIXED LINEAR ALCOHOLS	800	B	2
KETONE ALCOHOL OIL	700	B	3
DECYL ALCOHOL	700	C	3
BISPHENOL-A	700	C	3
ACETALDEHYDE - HYDRATION OF ETHYLENE	600	B	3
ASCORBIC ACID - VITAMIN C	600	C	3
POLYESTER POLYOLS	600	C	3
METHYL CHLORIDE	600	C	3
P-DICHLOROBENZENE	600	B	3
METHYL ETHYL KETONE	500	B	3
POLYVINYL ALCOHOL RESINS	500	C	3
SALICYLIC ACID	500	C	3
N-OCTYL-N-DECYL PHTHALATE	500	C	3
POLYPROPYLENE	500	B	3
MELAMINE	500	C	3
CHLOROBENZENE	500	B	3
ANTHELMINTICS	500	D	3
DIISOOCTAL PHTHALATE	400	C	3
HEXAMETHYLENEDIAMINE - ADIPONITRILE	400	C	3
SULFATED ETHOXYLATES - AEOS	400	C	2
TRIMETHYLAMINE	400	D	3
CARBARYL-SEVIN	400	D	3
PARAFORMALDEHYDE	400	D	3
LINDANE	400	C	3
TETRACYCLINE	300	D	3
GLYCERIN - EPICHLOROHYDRIN	300	C	3
ANILINE	300	C	3
VINYL ACETATE - FROM ACETYLENE	300	B	3
FISH AND SEAFOOD CANNING	300	C	2
POLYVINYL ACETATE RESINS	300	B	2
2,4-D - DIMETHYLAMINE SALT	300	C	3
MONOETHYLAMINE	300	C	3
ETHANOL	300	B	3
TRIETHYLAMINE	300	C	3
SYM-TRIMETHYLENE-TRINITRAMINE	300	C	3
SACCHARIN	300	C	3
DODECYLBENZENE SULFONIC ACID - ISOPROPYLEMINE SALT	200	C	3
ASPIRIN	200	D	3
MODACRYLIC FIBERS	200	C	3
DIETHYLAMINE	200	C	3
ETHANOLAMINE - MONO-,DI-,AND TRI	200	C	3
PYRETHRINS	200	D	3
ACETONE - FROM ISOPROPANOL	200	C	3
POLYRAM	200	C	3
TRICHLOROTRIFLUOROETHANE	200	D	3
DODECYLBENZENE SULFONIC ACID - TRIETHYLAMINE SALT	200	C	2
M-XYLENE	200	C	3
2,4-DICHLOROPHENOXY ACETIC ACID	200	C	3

Table 4 (continued). PRIORITIZATION LISTING - ORGANIC SOURCES

ISOOCTAL ALCOHOLS	200	C	3
2,4-DICHLOROPHENOXY ACETIC ACID ESTERS	200	D	3
EPOXY RESINS - MODIFIED	200	E	2
PENTACHLOROPHENYL - PCP	200	B	3
ETHYLENE GLYCOL	200	B	2
CHOLINE CHLORIDE	200	C	3
BUTYL OCTYL PHTHALATE	100	C	3
TETRAETHYL/TETRAMETHYL LEAD	100	C	3
METHYLENE DIPHENYLDIISOCYANATE	100	B	3
NITROANILINE	100	C	3
VITAMIN B COMPLEXES	100	D	3
POLYBUTADIENE	100	B	3
DICHLOROTETRAFLUOROETHANE	100	C	3
ETHYL ACRYLATE - CARBONYLATION OF ACETYLENE	100	D	3
ACETIC ACID - FROM BUTANE	100	B	3
PROPYLENE GLYCOL	100	C	3
SALICYLATES - EXCLUDING ASPIRIN	100	C	3
METHYL BROMIDE	100	C	3
DICHLOROVOS-VAPONA-DDVP	100	D	3
AMMONIUM ACETATE	90	D	3
MONOSODIUM GLUTAMATE	80	C	3
TOXAPHENE	80	C	3
CHLOROTRIFLUORO METHANE	80	D	3
BUTADIENE	80	B	2
AMMONIUM FORMATE	80	D	3
NITROCHLOROBENZENE	70	B	3
POLYSULFIDE RUBBER	70	C	3
DICHLORONAPTHO QUINONE	70	D	3
HEXACHLOROBENZENE	70	C	3
AMMONIUM CITRATE	70	D	3
BENZOIC ACID	70	C	3
AMMONIUM GLUTONATE	60	C	3
QUINOLINE	60	D	3
ETHYL ACETATE	60	C	3
SACCHARIN - VIA O-TOLUENE SULFONAMIDE	60	C	3
VINYLIDENE CHLORIDE	60	D	3
XYLENE SULFONIC ACID	60	C	3
P-NITROPHENOL	60	C	3
PERCHLOROETHYLENE - FROM TRICHLOROETHYLENE	60	B	3
NAPHTHENIC ACID - COPPER SALT	60	C	3
DIMETHYL PHTHALATE	60	C	3
DIAZINON	60	D	3
METHYL MERCAPTAN	50	D	3
PHOSGENE	50	B	3
METHANEARSONIC ACID - DISODIUM SALT - DSMA	50	C	3
BENZOYL CHLORIDE	50	D	3
2,4,5-T SALTS	50	D	3
ACRYLONITRILE - BUTADIENE - STYRENE RESIN	50	C	3
METHANEARSONIC ACID - DODECYL AND OCTYL AMMONIUM SALTS	50	C	3
PENTAERYTHRIOL TETRANITRATE	40	C	3
OCTYLPHENOL	40	C	3
CRESYLDIPHENYL PHOSPHATE	40	C	3
2-METHOXYETHANOL	40	C	3
ETHYLENE	40	B	2
NONENE - NON-LINEAR	40	C	3
ISOPROPANOL - DIRECT HYDRATION	30	B	3
1,1,2-TRICHLOROETHANE - FROM ETHYLENE DICHLORIDE	30	C	3
ETHION	30	D	3
PENICILLIN G - POTASSIUM	30	C	3
N-BUTYL ACRYLATE	30	C	3
TRICHLOROPHENOL - DOWICIDE 2	30	D	3
NITROCELLULOSE	30	B	3
PROPYLENE TETRAMER	30	C	3
DINITROTOLUENE	20	C	3
N-BUTYL ACETATE	20	C	3
ETHOXYLATED NONYLPHENOL	20	B	2
ETHYLENE DIAMINE	20	C	3
N-PROPYL ALCOHOL	20	D	3
RESORCINOL	20	D	3
BUTYLAMINE	20	D	3
ETHYL ACRYLATE - DIRECT ESTERIFICATION	20	D	3
CHLORDANE	20	C	3
VITAMIN A	20	C	3
DIELDRIN	20	D	3
CAPROLACTUM	10	C	3
TRICHLORFON - DIPTEREX	10	D	3
ATRAZINE	10	D	3

Table 4 (continued). PRIORITIZATION LISTING - ORGANIC SOURCES

VINYL BROMIDE	10	D	3
ETHYL ETHER	10	C	3
TOLUENE-2, 4-DIAMINE	10	B	2
ACROLEIN	10	B	3
POLYISOPRENE	10	C	3
PROPYLENE TRIMER	10	C	3
N-BUTYRALDEHYDE	10	C	3
PYROGALLIC ACID	10	D	3
CATECHOL	10	D	3
BUTYLENE DIMER - DIISOBUTYLENE	10	C	3
AMMONIUM TARTRATE	9	D	3
DIQUAT	9	D	3
POLYCARBONATE RESINS	9	B	3
POLYISOBUTYLENE - ISOPRENE BUTYL	9	C	3
DODECENE - NON-LINEAR	9	C	3
METHANEARSONIC ACID - MONOSODIUM SALT - MSMA	8	C	3
ETHOXYLATED OCTYLPHENOL	7	D	3
ETHOXYETHANOL	7	C	3
CYCLOHEXYLAMINE	7	C	3
XYLENE SULFONATE - SODIUM SALT	7	C	3
2-BUTOXYETHANOL	6	C	3
2,4,5-T	6	D	3
BENZENE	5	C	2
MEVINPHOS	5	D	3
METHANEARSONIC ACID - CALCIUM SALT - CALAR	5	C	3
ALLYL ALCOHOL	5	D	3
PETROLEUM REFINING - AROMATICS/ISOMERIZATION	5	B	2
PENICILLIN G - PROCAINE	5	C	3
DICHLOROBENZONITRILE	5	D	3
PHENYLMERCURY ACETATE - PMA - PMAS	5	D	3
ETHYL BENZENE	4	C	2
PROPIONIC ACID	4	C	3
DI-SYSTON	4	C	3
ETHYL PYROPHOSPHATE - TEPP	4	D	3
ETHOXYLATED MIXED LINEAR ALCOHOLS	4	C	2
DALAPON	4	D	3
PETROLEUM REFINING - ALKYLATION	3	C	2
CUMENE SULFONATE - AMMONIUM SALT	3	D	3
DI BUTYL PHTHALATE	3	C	2
DURSBAN	3	D	3
CUMENE SULFONIC ACID	2	D	3
TOLUENE SULFONIC ACID	2	D	3
DINITROBENZENE	2	D	3
1,5-CYCLOOCTADIENE	2	C	3
ALCOHOL SULFATE - SODIUM SALT	2	C	3
ISOPROPYL ACETATE	2	C	3
AMMONIUM BENZOATE	2	C	3
CAPTAN	2	D	3
AMMONIUM THIOCYANATE	2	D	3
DINITROPHENOL	1	D	3
XYLENE SULFONATE - AMMONIUM SALT	1	C	3
ALCOHOL SULFATES - TRIETHANOLAMINE SALT	1	C	3
NITROGLYCERINE	1	C	3
ALCOHOL SULFATES - AMMONIUM SALT	1	C	3
2-ETHOXYETHYL ACETATE	1	D	3
BENZONITRILE	1	D	3
CROTONALDEHYDE	1	D	3
METHYL ACETATE	1	C	3
AMYL ACETATE	1	D	3
LINEAR ALCOHOLS - ZIEGLER PROCESS	1	C	3
T-BUTYL ALCOHOL	1	C	3
NITROPARAFINS	1	B	3
HYDROXYLAMINE	1	D	3
XYLENE SULFONATE - POTASSIUM SALT	1	C	3
DI-2-ETHYLHEXYL ADIPATE	1	C	2
BRUCINE ALKALOID	1	D	3
ALLYL CHLORIDE	1	B	3
OLEIC ACID	1	C	2
GUTHION	1	C	3
N-BUTYRIC ACID	1	D	3
ETHYL BUTYRATE	1	C	3
CARBON BLACK - THERMAL	1	A	3
STYRENE - BUTADIENE COPOLYMER RESINS	1	B	2
DIMETHYL HYDRAZINE	1	D	3
HYDROXYLAMINE SULFATE	1	D	3

Table 5. PRIORITIZATION LISTING - OPEN SOURCES

OPEN SOURCES

SOURCE TYPE	IMPACT FACTOR	UL	CALC
FIELD FORMULATION OF PESTICIDES	2,000,000,000,000		5
UNPAVED ROADS	800,000,000,000	C	4
AGRICULTURAL TILLING	300,000,000,000	C	2
CONSTRUCTION ACTIVITIES	100,000,000,000	C	1
WIND EROSION OF SOIL FROM DORMANT LAND	70,000,000,000	C	2
BLASTING OF SULFUR STORAGE PILES	6,000,000,000	C	2
PARATHION APPLICATION ON CROPS	3,000,000,000	C	2
CRUSHED GRANITE	3,000,000,000	C	1
TOXAPHENE APPLICATION ON CROPS	2,000,000,000	C	2
CRUSHED SANDSTONE	2,000,000,000	C	1
HANDLING OF GRAIN	2,000,000,000	B	1
COTTON HARVESTING	2,000,000,000	B	2
CRUSHED LIMESTONE	1,000,000,000	C	1
TRANSPORT OF SAND AND GRAVEL	900,000,000	C	2
OPEN MINING OF COAL	500,000,000	C	2
COAL ASH DISPOSAL	400,000,000	C	1
LOADING OF SAND AND GRAVEL	400,000,000	C	2
GRAIN HARVESTING	300,000,000	B	2
BARITE MILLING	200,000,000	B	2
ABRASIVE CLEANING OF OUTDOOR STRUCTURES	200,000,000	D	1
CRUSHED STONE/TRAPROCK	200,000,000	C	1
DEFOLIATION OF COTTON	200,000,000	B	2
INDUSTRIAL SAND HANDLING	100,000,000	B	2
COAL FINES DISPOSAL	100,000,000	C	2
PAPER MILL BUILDING EMISSIONS	100,000,000	D	2
CRUSHING, SIZING OF SAND AND GRAVEL	100,000,000	C	2
OPEN STORAGE OF SAND AND GRAVEL	80,000,000	B	2
CHLORINATION OF SWIMMING POOLS	70,000,000	C	1
STORAGE OF ANIMAL RENDERINGS	60,000,000	D	1
POULTRY DRESSING	50,000,000	D	1
SIZING, GRINDING, FIBERIZING OF ASBESTOS	30,000,000	B	2
SAND AND GRAVEL UNLOADING	30,000,000	C	2
BUILDING DEMOLITION	30,000,000	D	1
HANDLING OF CONCRETE PRODUCTS	20,000,000	D	1
SCREENING, CRUSHING OF CLAY	20,000,000	C	2
H V TRANSMISSION LINES	20,000,000	C	1
COAL TRANSPORT	10,000,000	D	4
DISPOSAL OF ASBESTOS WASTE ORE	10,000,000	C	2
BEEF CATTLE FEEDLOTS	10,000,000	B	2
CONVEYING OF SAND AND GRAVEL	10,000,000	C	2
MINING AND BLASTING OF ASBESTOS ORE	10,000,000	B	2
PHOSPHATE ROCK OPEN STORAGE	10,000,000	A	2
PHOSPHATE ROCK LOADING	9,000,000	A	2
REFUSE ASH DISPOSAL	7,000,000	D	1
SEWERAGE CHLORINATION TANKS	7,000,000	C	1
LOADING READY-MIX CEMENT	6,000,000	B	2
STORAGE OF WOOD CHIPS	6,000,000	D	2
CLAY PROCESSING AREA	4,000,000	A	2
REFUSE UNLOADING	4,000,000	D	1
LOADING HYDRAULIC CEMENT	4,000,000	B	2
DISPOSAL OF CONCRETE BLOCK WASTES	3,000,000	D	1
STORAGE OF ASBESTOS ORE	2,000,000	B	2
TRANSPORT OF ASBESTOS ORE	2,000,000	B	2
TRANSPORT OF CLAY	900,000	D	2

Table 5 (continued). PRIORITIZATION LISTING - OPEN SOURCES

STORAGE OF SAWDUST	800.000	D	2
COAL CONVEYING	800.000	D	1
ALKALI AND CHLORINE PLANT WASTES	700.000	C	2
LOADING LIME	600.000	C	2
SEWERAGE TRICKLING FILTER	500.000	C	1
SAW MILL WASTE STORAGE	500.000	C	2
COAL STORAGE	300.000	A	2
DRILLING OIL AND GAS - BEFORE WELL HIT	200.000	B	2
OPEN MINING OF TALC	200.000	C	2
ASBESTOS PROCESSING AREA	100.000	D	2
TRANSPORT OF SULFUR	100.000	C	2
LOADING OF FINISHED CLAY	90.000	D	2
STORAGE OF RAW CLAY	90.000	D	2
CLAY SILOS - KAOLIN	70.000	A	2
SEWERAGE AERATION	60.000	C	1
STORAGE OF SULFUR	60.000	C	2
OPEN MINING AND GRINDING OF PUMICE	50.000	C	2
TRANSPORT OF TALC ORE	50.000	C	2
STORAGE OF TALC ORE	40.000	C	2
SEWERAGE VACCUUM FILTER	30.000	C	1
BARITE STORAGE	30.000	B	2
BARITE TRANSPORT	20.000	B	2
OPEN MINING AND STORAGE OF MICA	20.000	C	2
OPEN CLAY MINING	20.000	D	2

SECTION III

APPENDIXES

DETAILED EXAMPLES USING PRIORITIZATION MODEL

A. Use of Model with Common Inputs

B. Example of Population Sensitive Calculation

C. Location Sensitive Calculations

D. Example of Detailed Calculation

E. Example of Open Sources Calculation

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APPENDIX A

USE OF MODEL WITH COMMON IMPUTS

Since published standards exist for the five criteria pollutants, it was deemed inappropriate to use TLV's for these materials. Instead, the primary standard, S, was set equal to the hazard potential factor, F.[a] Common constants used were:

u = wind speed = 4.5 m/sec
e = 2.72
π = 3.14

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[a] In the organic materials category, emissions that were specifically identified as organic were termed "named hydrocarbons" to differentiate them from the criteria hydrocarbon emissions of indeterminate composition. The hazard potential factor for these materials was defined as follows:

$$F = \begin{cases} TLV \cdot K \text{ if } TLV \cdot K < S_{HC} \\ S_{HC} \text{ if } TLV \cdot K \geq S_{HC} \end{cases}$$

where S_{HC} = hydrocarbon standard = 0.16 mg/m^3

and $K = (40/168)(1/100)$

Table A-1 gives the population and area data for the 50 states.[4] Table A-2 lists the ambient air quality for the criteria pollutants.[5]

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[4]The World Almanac and Book of Facts, 1974.

[5]Air Quality Data - 1972 Annual Statistics. Publication No. EPA-450/2-74-001.

Table A-1. POPULATION AND AREA DATA BY STATE

	STATE	POPULATION	POPULATION FRACTION	AREA	AREA FRACTION	NO OF COUNTIES	POPULATION DENSITY
1	ALABAMA	3521000.	0.0169093	51609.	0.01428	67.	68.225
2	ALASKA	325000.	0.0015608	586412.	0.16221	29.	0.554
3	ARIZONA	1963000.	0.0094272	113909.	0.03151	14.	17.233
4	ARKANSAS	2008000.	0.0096463	53104.	0.01469	75.	37.815
5	CALIFORNIA	20411000.	0.0980223	158693.	0.04390	58.	128.619
6	COLORADO	2364000.	0.0113529	104247.	0.02884	63.	22.677
7	CONNECTICUT	3080000.	0.0147915	5009.	0.00139	8.	614.893
8	DELAWARE	571000.	0.0027422	2057.	0.00057	3.	277.589
9	FLORIDA	7347000.	0.0352834	58560.	0.01620	67.	125.461
10	GEORGIA	4733000.	0.0227299	58876.	0.01629	159.	80.389
11	HAWAII	816000.	0.0039188	6450.	0.00178	5.	126.512
12	IDAHO	755000.	0.0036258	83557.	0.02311	44.	9.036
13	ILLINOIS	11244000.	0.0539985	56400.	0.01560	102.	199.362
14	INDIANA	5286000.	0.0253856	36291.	0.01004	92.	145.656
15	IOWA	2884000.	0.0138502	56290.	0.01557	99.	51.255
16	KANSAS	2268000.	0.0108919	82264.	0.02276	105.	27.570
17	KENTUCKY	3306000.	0.0158768	40395.	0.01117	120.	81.842
18	LOUISIANA	3738000.	0.0179515	48523.	0.01342	64.	77.036
19	MAINE	1026000.	0.0049273	33215.	0.00919	16.	30.890
20	MARYLAND	4800000.	0.0230516	10577.	0.00293	23.	453.815
21	MASSACHUSETTS	5796000.	0.0278349	8257.	0.00228	14.	701.950
22	MICHIGAN	9013000.	0.0432843	58216.	0.01610	83.	154.820
23	MINNESOTA	3877000.	0.0186190	84068.	0.02325	87.	46.117
24	MISSISSIPPI	2256000.	0.0108343	47716.	0.01320	82.	47.280
25	MISSOURI	4747000.	0.0227971	69686.	0.01928	114.	68.120
26	MONTANA	716000.	0.0034385	147138.	0.04070	56.	4.866
27	NEBRASKA	1528000.	0.0073381	77227.	0.02136	93.	19.786
28	NEVADA	533000.	0.0025597	110540.	0.03058	16.	4.822
29	NEW HAMPSHIRE	774000.	0.0037171	9304.	0.00257	10.	83.190
30	NEW JERSEY	7349000.	0.0352930	7836.	0.00217	21.	937.851
31	NEW MEXICO	1076000.	0.0051674	121666.	0.03366	32.	8.844
32	NEW YORK	18367000.	0.0882062	49576.	0.01371	62.	370.482
33	N CAROLINA	5221000.	0.0250735	52586.	0.01455	100.	99.285
34	N DAKOTA	634000.	0.0030447	70665.	0.01955	53.	8.972
35	OHIO	10722000.	0.0514916	41222.	0.01140	88.	260.104
36	OKLAHOMA	2633000.	0.0126448	69919.	0.01934	77.	37.658
37	OREGON	2185000.	0.0104933	96981.	0.02683	36.	22.530
38	PENNSYLVANIA	11905000.	0.0571729	45333.	0.01254	67.	262.612
39	RHODE ISLAND	969000.	0.0046536	1214.	0.00034	5.	798.188
40	S CAROLINA	2688000.	0.0129089	31055.	0.00859	46.	86.556
41	S DAKOTA	680000.	0.0032657	77047.	0.02131	67.	8.826
42	TENNESSEE	4072000.	0.0195555	42244.	0.01169	95.	96.392
43	TEXAS	11604000.	0.0557274	267338.	0.07395	254.	43.406
44	UTAH	1127000.	0.0054123	84916.	0.02349	29.	13.272
45	VERMONT	460000.	0.0022091	9609.	0.00266	14.	47.872
46	VIRGINIA	4765000.	0.0228836	40817.	0.01129	96.	116.741
47	WASHINGTON	3418000.	0.0164147	68192.	0.01886	39.	50.123
48	W VIRGINIA	1795000.	0.0086204	24181.	0.00669	55.	74.232
49	WISCONSIN	4526000.	0.0217358	56154.	0.01553	72.	80.606
50	WYOMING	346000.	0.0016616	97914.	0.02709	23.	3.534
TOTALS		208228064.	1.0000	3615055.	1.0000		

Legend

Area is given in square miles.

Population density is given in persons/mi^2.

Table A-2. AMBIENT AIR QUALITY DATA BY STATE FOR CRITERIA POLLUTANTS

STATE	PARTICULATES		CARBON MONOXIDE		SULFR DIOXIDE		NITGN DIOXIDE		HYDROCARBONS	
1	63	0.22386E-03	2	0.15200E-01	13	0.55200E-04	13	0.71400E-04	2	0.10839E-01
2	18	0.34200E-03	1	0.46000E-01	1	0.28000E-04	1	0.96500E-04	0	0.00000E+00
3	32	0.31672E-03	2	0.59200E-01	7	0.11600E-04	5	0.56900E-04	2	0.48880E-02
4	32	0.14731E-03	0	0.40000E-01	2	0.16500E-04	2	0.80300E-04	0	0.00000E+00
5	19	0.21937E-03	51	0.21500E-01	16	0.33800E-04	14	0.17820E-03	37	0.95077E-02
6	69	0.28899E-03	1	0.49400E-01	2	0.21500E-04	2	0.86300E-04	1	0.41790E-02
7	26	0.18385E-03	0	0.40000E-01	4	0.62200E-04	4	0.15340E-03	0	0.00000E+00
8	16	0.17169E-03	0	0.40000E-01	3	0.53700E-04	3	0.88700E-04	0	0.00000E+00
9	45	0.12393E-03	6	0.23900E-01	34	0.17430E-03	22	0.11760E-03	1	0.21940E-02
10	31	0.13945E-03	2	0.25000E-01	13	0.40100E-04	13	0.42100E-04	1	0.51870E-02
11	14	0.14300E-03	1	0.37400E-01	12	0.53700E-04	11	0.43700E-04	0	0.00000E+00
12	30	0.26080E-03	0	0.40000E-01	0	0.80000E-04	0	0.10000E-03	0	0.00000E+00
13	54	0.11204E-03	1	0.27600E-01	38	0.15470E-03	4	0.14010E-03	1	0.60510E-02
14	128	0.20084E-03	3	0.12100E-01	66	0.21600E-03	40	0.10740E-03	0	0.00000E+00
15	30	0.21510E-03	2	0.13200E-01	2	0.53000E-04	2	0.84000E-04	0	0.00000E+00
16	59	0.19697E-03	5	0.26200E-01	30	0.89200E-04	29	0.32700E-04	0	0.00000E+00
17	90	0.17910E-03	7	0.27200E-01	87	0.86700E-04	35	0.41800E-04	7	0.81224E-02
18	12	0.17267E-03	3	0.18900E-01	17	0.95500E-04	4	0.10550E-03	0	0.00000E+00
19	7	0.83000E-04	0	0.40000E-01	6	0.43700E-04	1	0.35000E-04	0	0.00000E+00
20	85	0.15182E-03	19	0.19200E-01	49	0.79700E-04	38	0.71500E-04	12	0.52366E-02
21	52	0.15679E-03	3	0.32600E-01	53	0.11640E-03	42	0.77000E-04	0	0.00000E+00
22	109	0.20440E-03	3	0.13200E-01	24	0.95500E-04	6	0.13270E-03	0	0.00000E+00
23	59	0.14237E-03	3	0.19900E-01	18	0.11730E-03	3	0.95300E-04	2	0.56525E-02
24	2	0.93000E-04	0	0.40000E-01	2	0.26000E-04	2	0.61800E-04	0	0.00000E+00
25	49	0.20590E-03	10	0.23100E-01	4	0.73500E-04	4	0.92300E-04	9	0.67977E-02
26	2	0.92000E-04	0	0.40000E-01	1	0.13000E-04	1	0.24000E-04	0	0.00000E+00
27	36	0.16975E-03	1	0.34840E+00	4	0.11720E-03	3	0.65500E-04	0	0.00000E+00
28	41	0.37400E-03	1	0.27600E-01	3	0.46270E-03	0	0.10000E-03	1	0.50540E-02
29	26	0.14292E-03	0	0.40000E-01	4	0.10750E-03	4	0.25600E-04	0	0.00000E+00
30	79	0.13514E-03	22	0.31000E-01	8	0.73200E-04	8	0.10980E-03	4	0.10846E-01
31	28	0.24800E-03	1	0.31000E-01	8	0.25200E-04	7	0.49700E-04	0	0.00000E+00
32	233	0.15260E-03	13	0.75000E-02	34	0.13360E-03	8	0.10540E-03	10	0.72356E-02
33	199	0.18055E-03	2	0.14600E-01	156	0.69900E-04	72	0.45000E-04	1	0.65300E-02
34	16	0.22238E-03	0	0.40000E-01	0	0.80000E-04	0	0.10000E-03	0	0.00000E+00
35	137	0.27228E-03	12	0.29800E-01	67	0.14450E-03	30	0.14640E-03	2	0.82795E-02
36	95	0.19453E-03	3	0.42600E-01	27	0.79400E-04	19	0.51900E-04	0	0.00000E+00
37	48	0.16067E-03	2	0.35400E-01	1	0.99000E-04	1	0.12500E-03	1	0.34720E-02
38	105	0.24043E-03	2	0.31570E+00	14	0.71300E-04	14	0.10190E-03	1	0.59850E-02
39	23	0.14004E-03	2	0.18100E-01	18	0.14780E-03	15	0.84000E-04	0	0.00000E+00
40	75	0.20008E-03	0	0.40000E-01	38	0.44100E-04	16	0.47800E-04	0	0.00000E+00
41	2	0.13650E-03	1	0.70000E-02	1	0.70000E-05	1	0.38000E-04	0	0.00000E+00
42	98	0.18928E-03	4	0.21400E-01	37	0.29000E-04	23	0.51000E-04	0	0.00000E+00
43	192	0.23108E-03	1	0.17000E-01	13	0.26100E-04	13	0.94100E-04	0	0.00000E+00
44	8	0.43513E-03	4	0.49400E-01	1	0.50000E-04	1	0.15900E-03	0	0.00000E+00
45	2	0.16000E-03	0	0.40000E-01	0	0.80000E-04	0	0.10000E-03	0	0.00000E+00
46	122	0.19800E-03	9	0.27500E-01	49	0.79300E-04	6	0.86300E-04	1	0.87780E-02
47	57	0.21718E-03	10	0.23600E-01	4	0.52800E-04	10	0.86800E-04	3	0.57633E-02
48	38	0.20984E-03	1	0.17800E-01	15	0.11630E-03	1	0.11500E-03	0	0.00000E+00
49	7	0.14586E-03	1	0.12100E-01	3	0.61300E-04	3	0.77200E-04	0	0.00000E+00
50	4	0.95750E-04	0	0.40000E-01	2	0.13500E-04	2	0.28500E-04	0	0.00000E+00

LEGEND

1. Column 1 is the state code which corresponds to that used in Table A-1.
2. The columns of integers preceeding the corresponding criteria levels are the number of points used in computing that state average.
3. For particulates and SO_2, the maximum observed 24-hr averages were used in the subsequent state average calculation.
4. For NO_2, the annual average values from individual stations were used to compute the state average.
5. For CO and hydrocarbons, the maximum observed 1-hr averages were used.
6. A value of zero for a given state indicates unreported data. For those points we set $\chi'/S = 1.0$.

APPENDIX B

EXAMPLE OF POPULATION SENSITIVE CALCULATION

1. SOURCE INFORMATION

- Source Type: Asphalt Paving-Hot Mix

- Basic Data: Table B-1 contains the basic data which will be used to calculate the impact factor, I_x.

- Additional Data:

  Frequency of operation (f) = 0.17

  Total capacity of asphalt industry (CAP) = 2.9478 x 10^8 Mg/yr

  Number of materials emitted (N) = 7

  Height of emissions (h) = 15.24

Table B-1. ASPHALT PAVING-HOT MIX INPUT DATA

Pollutant	Primary standard, g/m^3	TLV, g/m^3	Emission factor, g/Mg product
Particulates	$S_1 = 2.6 \times 10^{-4}$		$E_1 = 800.14$
Sulfur oxides	$S_2 = 3.65 \times 10^{-4}$		$E_2 = 400.07$
Nitrogen oxides	$S_3 = 1.0 \times 10^{-4}$		$E_3 = 45.01$
Hydrocarbons	$S_4 = 1.60 \times 10^{-4}$		$E_4 = 3.70$
Carbon monoxide	$S_5 = 4.00 \times 10^{-2}$		$E_5 = 5.00$
POM[a]		$TLV_6 = 5.1 \times 10^{-6}$	$E_6 = 3.60 \times 10^{-3}$
Aldehydes		$TLV_7 = 3.000 \times 10^{-3}$	$E_7 = 4.95 \times 10^{-1}$

[a] POM = Polycyclic Organic Material.

2. PROCEDURE FOR CALCULATION OF IMPACT FACTOR

The equation used for determining impact factor is given as:

$$I_x = \sum_{j=1}^{K_x} Pj \left\{ \sum_{i=1}^{N} \left[\left(\frac{\bar{\chi} i_j}{F_i} \right)^2 \left(\frac{\chi' i_j}{S_i} \right) \right] \right\}^{1/2} \qquad \text{(B-1)}$$

For the asphalt industry having plants located in all 50 states and emitting seven pollutants, the above equation is written as:

$$I_x = \sum_{j=1}^{50} Pj \left\{ \sum_{i=1}^{7} \left[\left(\frac{\bar{\chi} i_j}{F_i} \right)^2 \left(\frac{\chi' i_j}{S_i} \right) \right] \right\}^{1/2}$$

or

$$I_x = P_1 \left\{ \sum_{i=1}^{7} \left[\left(\frac{\bar{\chi}_{i1}}{F_i} \right)^2 \left(\frac{\chi'_{i1}}{S_i} \right) \right] \right\}^{1/2}$$

$$+ P_2 \left\{ \sum_{i=1}^{7} \left[\left(\frac{\bar{\chi}_{i2}}{F_i} \right)^2 \left(\frac{\chi'_{i2}}{S_i} \right) \right] \right\}^{1/2}$$

$$+ \cdots\cdots P_{50} \left\{ \sum_{i=1}^{7} \left[\left(\frac{\bar{\chi}_{i50}}{F_i} \right)^2 \left(\frac{\chi'_{i50}}{S_i} \right) \right] \right\}^{1/2}$$

This can be simplified as:

$$I_x = I_{x_1} + I_{x_2} + \cdots\cdots\cdots I_{x_{50}} \qquad \text{(B-2)}$$

where

$$I_{x_1} = P_1 \left\{ \sum_{i=1}^{7} \left[\left(\frac{\bar{\chi}_{i1}}{F_i} \right)^2 \left(\frac{\chi'_{i1}}{S_i} \right) \right] \right\}^{1/2} \qquad \text{(B-3)}$$

I_{x_1} can be defined as the contribution to the total impact factor I_x by the 1st state, i.e., Alabama. I_{x_1} can also be written for the seven emitted species as:

$$I_{x_1} = \left\{ P_1^2 \left[\left(\frac{\bar{\chi}_{11}}{F_1} \right)^2 \left(\frac{\chi'_{11}}{S_1} \right) \right] + P_1^2 \left[\left(\frac{\bar{\chi}_{21}}{F_2} \right)^2 \left(\frac{\chi'_{21}}{S_2} \right) \right] + \ldots\ldots\ldots P_1^2 \left[\left(\frac{\bar{\chi}_{71}}{F_7} \right)^2 \left(\frac{\chi'_{71}}{S_7} \right) \right] \right\}^{1/2} \qquad \text{(B-4)}$$

To calculate the total impact factor, I_x, it is necessary to first determine I_{x_1}, I_{x_2}, ... $I_{x_{50}}$, the contribution to the impact factor by each state.

3. CONTRIBUTION TO THE IMPACT FACTOR BY THE FIRST STATE I_{x_1} (ALABAMA)

a. Basic Information for Alabama

Stored data for state : 01 (Alabama)
Population fraction $PF_1 = 1.69 \times 10^{-2}$
Population density $P_1 = 26.34$ persons/km^2

b. Capacity for Alabama (CAP_1)

$CAP_1 = (PF_1)(CAP)$

$CAP_1 = (1.69 \times 10^{-2})(2.95 \times 10^8)$

$CAP_1 = 4.985 \times 10^6$ Mg/yr

c. Emission rate for particulate for Alabama (Q_1)

$$Q_1 = \frac{1}{f} (YPS)(CAP_1)(E_1)$$

where:

$$YPS = \frac{3.1688088 \times 10^{-8} \text{ years}}{\text{second}}$$

$$\therefore Q_1 = \left(\frac{1.0}{0.17}\right)\left(3.17 \times 10^{-8}\right)\left(4.985 \times 10^{6}\right)\left(800.14\right)$$

$$Q_1 = 743.47 \text{ g/sec}$$

Dimensional analysis shows

$$Q_1 = \left(\frac{\text{years}}{\text{sec}}\right) \frac{\text{Mg}}{\text{year}} \times \frac{\text{g}}{\text{Mg}} = \frac{\text{g}}{\text{sec}}$$

d. χ_{max} for particulates for Alabama (χ_{max_1})

$$\chi_{max_1} = \frac{2Q_1}{\pi h^2 e\bar{u}}$$

where:

$$h^2 = (15.24)^2 \text{ m}^2$$

$$h^2 = 232.26 \text{ m}^2$$

$$\chi_{max_1} = \frac{2 (734.47) \text{ g/m}^3}{(3.14)\ (232.26)\ (2.72)\ (4.47)}$$

$$\chi_{max_1} = 1.65 \times 10^{-1} \text{ g/m}^3$$

Dimensional analysis shows

$$\chi_{max} = \frac{\text{g} \times \text{sec}^{-1}}{\text{m}^2(\text{msec}^{-1})} = \frac{\text{g}}{\text{m}^3}$$

e. Hazard Potential Factor (F_1) for particulates for Alabama

$F_1 = S_1 = 2.6 \times 10^{-4}$ g/m^3

(All states have same F_1)

f. Other Pollutants for Alabama

Using the procedure described in Section 3.a through 3.c above, values for Q_1, χ_{max_1}, and F are calculated for all pollutants from Alabama. These values are then used to calculate the impact factor for Alabama according to the following formula:

$$I_{x_1} = \left\{ P_1^2 \left[\left(\frac{\bar{\chi}_{11}}{F_1} \right)^2 \left(\frac{\chi'_{11}}{S_1} \right) \right] + P_1^2 \left[\left(\frac{\bar{\chi}_{21}}{F_2} \right)^2 \left(\frac{\chi'_{21}}{S_2} \right) \right] + \cdots\cdots\cdots P_1^2 \left[\left(\frac{\bar{\chi}_{71}}{F_7} \right)^2 \left(\frac{\chi'_{71}}{S_7} \right) \right] \right\}^{1/2} \qquad \text{(B-5)}$$

where I_{x_1} = impact factor contribution by each of seven pollutants from Alabama

P_1 = population density of Alabama

$\bar{\chi}_{11}$ = χ_{max} for particulate in Alabama

χ'_{11} = particulate ambient air level in Alabama
= 2.24×10^{-4} g/m^3

F_1 = hazard potential factor for particulate

S_1 = primary standard for particulate

$\bar{\chi}_{21}$ = χ_{max} for sulfur oxides in Alabama

χ'_{21} = sulfur oxide ambient air level in Alabama

F_2 = hazard potential factor for sulfur oxides

S_2 = primary standard for sulfur oxide

Other single digit subscripts identify specific pollutants as listed in Table B-1, e.g., F_3, F_4, F_5, F_6 and F_7 refer to the hazard potential factor for nitrogen oxides, hydrocarbons, carbon monoxide, polycyclic organic material and aldehydes, respectively. In double digit subscripts, the first digit identifies the pollutant as before, while the second digit identifies the state, e.g., $\bar{\chi}_{51}$, $\bar{\chi}_{52}$ and $\bar{\chi}_{53}$ refer to χ_{max} for carbon monoxide in Alabama, Alaska, and Arizona, respectively.

g. Impact Factor Contributions by All Seven Pollutants for Alabama

Since, $$\frac{\chi'_{11}}{S_1} = \frac{2.24 \times 10^{-4}}{2.6 \times 10^{-4}} = 0.86$$

then $$\frac{\chi'_{11}}{S_1} = 1.0$$

and, $$I_{x_1} = \left\{26.35^2 \left[\left(\frac{1.65 \times 10^{-1}}{2.6 \times 10^{-4}}\right)(1.0)\right] + \ldots.\right\}^{1/2}$$

$$I_{x_1} = \left[(694.3)(633) + \ldots..\right]^{1/2}$$

I_{x_1} = 18,327 (i.e., the impact factor contribution for all seven pollutants for Alabama)

Dimensional analysis shows

$$I_{x_1} = \left\{(\text{persons/km}^2)^2 \left[\left(\frac{g/m^3}{g/m^3}\right)^2 \left(\frac{g/m^3}{g/m^3}\right)\right]\right\}^{1/2}$$

or $$I_{x_1} = \text{persons/km}^2$$

4. CONTRIBUTION TO THE IMPACT FACTOR BY THE SECOND STATE (ALASKA)

a. Basic Information for Alaska

Stored data for state : 02 (Alaska)

Population fraction PF_2 = 1.56×10^{-3}

Population density P_2 = 2.14×10^{-1} persons/km^2

b. Capacity for Alaska (CAP_2)

$$CAP_2 = (PF_2)(CAP)$$
$$CAP_2 = (1.56 \times 10^{-3})(2.95 \times 10^{8})$$
$$CAP_2 = 4.60 \times 10^{5} \text{ Mg/year}$$

c. Emission rate for particulate for Alaska (Q_2)

$$Q_2 = \frac{1.0}{f} (YPS)(CAP_2)(E_1)$$

$$Q_2 = \frac{1.0}{0.17} (3.17 \times 10^{-8})(4.60 \times 10^{5})(800.14)$$

$$Q_2 = 68.6 \text{ g/sec}$$

d. χ_{max} for particulate for Alaska (χ_{max_2})

$$\chi_{max_2} = \frac{2\ (68.6)}{(232.26)(3.14)(2.72)(4.47)} \text{ g/m}^3$$

$$\chi_{max_2} = 1.55 \times 10^{-2} \text{ g/m}^3$$

e. Other Pollutants for Alaska

Similarly, Q_2, χ_{max_2}, and F are calculated for all pollutants from Alaska and these values are used to calculate the

impact factor for Alaska using the following equation:

$$I_{x_2} = \left\{ P_2^2 \left[\left(\frac{\bar{x}_{12}}{F_1} \right)^2 \left(\frac{x'_{12}}{S_1} \right) \right] + P_2^2 \left[\left(\frac{\bar{x}_{22}}{F_2} \right)^2 \left(\frac{x'_{22}}{S_2} \right) \right] + \ldots\ldots\ldots P_2^2 \left[\left(\frac{\bar{x}_{72}}{F_7} \right)^2 \left(\frac{x'_{72}}{S_7} \right) \right] \right\}^{1/2} \qquad \text{(B-6)}$$

substituting:

$$I_{x_2} = \left\{ (2.14 \times 10^{-1})^2 \left[\left(\frac{1.55 \times 10^{-2}}{2.60 \times 10^{-4}} \right)^2 (1.0) \right] + \ldots \right\}^{1/2}$$

$$I_{x_2} = \left\{ 4.6 \times 10^{-2} \ (59.6)^2 + \ldots\ldots\ldots\ldots \right\}^{1/2}$$

where $I_{x_2} = 15.5$ = sum of impact factor contributions by each of seven pollutants for Alaska.

5. CONTRIBUTION TO THE IMPACT FACTOR BY THE REMAINING STATES

Using the same procedure as outlined above for Alabama and Alaska, the respective contributions of each of the remaining 48 states to the impact factor are calculated. These calculations will not be repeated, but follow by induction. Therefore, the following relationship is achieved.

$$I_x = I_{x_1} + I_{x_2} + I_{x_3} + \ldots\ldots\ldots\ldots\ldots I_{x_{50}}$$

Finally, for Asphalt Paving-Hot Mix,

$$I_x = 3{,}221{,}290$$

and, after rounding to one significant figure,

$$I_x = 3{,}000{,}000$$

The input data form used for prioritization is shown in Table B-2.

Table B-2.

DP-1

POPULATION SENSITIVE PRIORITIZATION DATA

Log No. _____

Confidence Level B

CATEGORY Organic Chemicals

SOURCE DESCRIPTION Asphalt Paving - Hot Mix

SCC 3-05-002-99

SOURCE CAPACITY 2.9478×10^{8} Megagrams/year

FREQUENCY OF OPERATION 17 (% OF YEAR)

NUMBER OF MATERIALS EMITTED 7

NUMBER OF PLANTS/SITES 4800

AVERAGE HEIGHT OF EMISSION 15.24 Meters

MATERIAL EMITTED	TLV (g/m^3)	EMISSION FACTOR (g/Mg)	REFERENCE
PARTICULATE		800.14	Vandegrift, A.E., et al.
SOX		400.07	"Particulate Emission Syst.
NOX		45.01	Study." Volume I - Mass
HC		3.70	Emissions. MRI. NTIS
CO		5.00	# PB203-128
POM	5.10×10^{-6}	3.60×10^{-3}	Hangebrauch, R. P.,
Aldehydes	3.00×10^{-3}	4.95×10^{-1}	VonLehmden, D. J., and
			Meeker, J. E. "Sources of
			Polynuclear Hydrocarbons in
			the Atmosphere." Environmental
			Health Series. AIR-136.
			PB 174706
			MRC Engineering Estimates

APPENDIX C

LOCATION SENSITIVE CALCULATIONS

1. SOURCE INFORMATION

- Source Type: Coal-Fired Steam Electric Utilities

- Input Data:

  Total Capacity (CAP) = 3.9×10^8 Mg/yr coal burned
  Frequency of operation (f) = 1.0
  Number of materials emitted (N) = 19
  Height of emission (h) = 82.3 m

2. IMPACT FACTOR CALCULATION

The following equation will be used to calculate the impact factor for the first state:

$$I_{x_1} = P_1 \left\{ \sum_{i=1}^{19} \left[\left(\frac{\bar{\chi}_{i1}}{F_i} \right)^2 \left(\frac{\chi'_{i1}}{S_i} \right) \right] \right\}^{1/2} \qquad \text{(C-1)}$$

Since there are 19 materials emitted in each of the states the calculations will be shown for only three materials (particulate, sulfur oxides, and aldehydes) in one state (Alabama), and the remaining calculation steps follow by induction.

a. Data for First State: 01 (Alabama)

Population density (P_1) = 26.3 persons/km^2

Capacity (CAP_1) = 1.842×10^7 Mg/yr

$\chi'_{11} = 2.24 \times 10^{-4}$ g/m^3

$\chi'_{21} = 1.08 \times 10^{-5}$ g/m^3

b. For Particulates

Emission factor (E_1) = 15,600 g/Mg of coal burned

$$Q_1 = \left(\frac{1}{f}\right)(YPS)(CAP_1)(E_1)$$

$$Q_1 = \left(\frac{1.0}{1.0}\right)(3.17 \times 10^{-8})(1.842 \times 10^7)(15{,}600)$$

$$Q_1 = 9{,}109 \text{ g/sec}$$

$$\chi_{max} = \frac{2Q}{\pi H^2 e \bar{u}}$$

$$\chi_{max} = \frac{2\,(9109)}{(3.14159)(6773.3)(2.72)(4.47)}$$

$$\chi_{max} = 0.0705 \text{ g/m}^3$$

Defining $A_1 = \left(\frac{\bar{\chi}_{11}}{\bar{F}_1}\right)^2 \left(\frac{\chi'_{11}}{S_1}\right)$

and since $\frac{\chi'_{11}}{S_1} < 1.0$, then set $\frac{\chi'_{11}}{S_1} = 1.0$

$$A_1 = \left(\frac{0.0705}{2.60 \times 10^{-4}}\right)^2 (1.0)$$

$$A_1 = 73524$$

c. For Sulfur Oxides

SO_x emission factor $(E_2) = 4.75 \times 10^4$ g/Mg

$$Q_2 = \left(\frac{1}{f}\right)(YPS)(CAP_1)(E_2)$$

$$= \left(\frac{1.0}{1.0}\right)(3.17 \times 10^{-8})(1.842 \times 10^7)(4.75 \times 10^4)$$

$$Q_2 = 27{,}736 \text{ g/sec}$$

$$\chi_{max} = \frac{2Q}{\pi e u h^2}$$

$$= \frac{(2)(27736)}{(38.43)(82.3)^2}$$

$$\chi_{max} = 0.213 \text{ g/m}^3$$

Defining $A_2 = \left(\frac{\bar{\chi}_{21}}{F_2}\right)^2 \left(\frac{\chi'_{21}}{S_2}\right)$

$$= \left(\frac{0.213}{3.65 \times 10^{-4}}\right)^2 (1.0)$$

$$A_2 = 340544$$

d. For Aldehydes

Aldehyde emission factor $(E_6) = 2.5$ g/Mg

$$Q_7 = \left(\frac{1}{f}\right)(YPS)(CAP_1)(E_6)$$

$$= \left(\frac{1.0}{1.0}\right)(3.17 \times 10^{-8})(1.842 \times 10^7)(2.5)$$

$$Q_7 = 1.46 \text{ g/sec}$$

$$\chi_{max} = \frac{(2)(1.46)}{(38.43)(82.3)^2}$$

$$\chi_{max} = 1.12 \times 10^{-5} \text{ g/m}^3$$

Defining $A_7 = \left(\frac{\bar{\chi}_{71}}{F_7}\right)^2 \left(\frac{\chi'_{71}}{S_7}\right)$

Since S_7 is undefined for aldehydes, then:

$$\frac{\chi'_{71}}{S_7} = 1.0$$

and

$$F_7 = (\text{TLV}) \left(\frac{40}{168}\right)\left(\frac{1}{100}\right)$$

Since aldehyde TLV = 3×10^{-3} g/m^3

then $$F_7 = (3 \times 10^{-3})(2.38 \times 10^{-3})$$

$$F_7 = 7.14 \times 10^{-6} \text{ g/m}^3$$

and $$A_7 = \left(\frac{1.12 \times 10^{-5}}{7.14 \times 10^{-6}}\right)^2 (1.0)$$

$$A_7 = 2.46$$

then $$I_{x_1} = P_1 (A_1 + A_2 + ... + A_7 + ... + A_{19})^{1/2}$$

$$I_{x_1} = (26.3)(73524. + 340544. + ... + 2.5 + ... + A_{19})^{1/2}$$

$$I_{x_1} = 50,421$$

The above procecure is repeated for the remaining states to obtain:

$$I_x = I_{x_1} + I_{x_2} + I_{x_3} + ... + I_{x_{50}}$$

$$I_x = 50421 + ... + I_{x_{50}}$$

$$I_x = 2,289,560$$

and after rounding,

$$I_x = 2,000,000$$

The input data forms used for the above location sensitive calculations are shown in Tables C-1 through C-3.

Table C-1.

OF 2

LOCATION SENSITIVE PRIORITIZATION DATA

Confidence Level B

CATEGORY Combustion

SOURCE DESCRIPTION Coal-Fired Steam Electric Utilities

SCC

TOTAL PRODUCTION (Fuel Consumption) 4.30×10^8 (TONS/YEAR)

FREQUENCY OF OPERATION 100 (% OF YEAR)

NUMBER OF PLANTS/SITES

NUMBER OF MATERIALS EMITTED 19

MATERIAL EMITTED	TLV (g/m^3)	EMISSION FACTOR (lbs/ton)	AVG. EMISSION HEIGHT(ft)	REFERENCE
PARTICULATE		31.2	270	
SOX		95.0		
NOX		18		
HC		0.3		
CO		1.0		
Aldehydes	3×10^{-3}	0.005		
Arsenic	5×10^{-4}	3×10^{-3}		
Beryllium	2×10^{-6}	3.7×10^{-3}		
Manganese	5×10^{-3}	8×10^{-2}		
Mercury	1×10^{-5}	4×10^{-4}		
Nickel	1×10^{-3}	6×10^{-4}		
Vanadium	5×10^{-5}	7×10^{-4}		
Barium	5×10^{-4}	15×10^{-3}		
Boron	10×10^{-3}	18×10^{-3}		
Cadmium	1×10^{-4}	1×10^{-3}		
Copper	1×10^{-3}	2.5×10^{-3}		
POM	10×10^{-6}	1.4×10^{-6}		
Selenium	2×10^{-4}	2.5×10^{-3}		
Zinc	5×10^{-3}	17×10^{-3}	270	

Table C-2.

DF 2a

LOCATION SENSITIVE PRIORITIZATION DATA
STATE INFORMATION

SOURCE DESCRIPTION Coal-Fired Steam-Electric Utilities

AVERAGE PLANT SIZE _____ (TONS/YEAR)

NUMBER OF STATES 42

STATE CODE (XX)	STATE PRODUCTION (TONS/YEAR)	NUMBER OF PLANTS	REFERENCE
1	2.03×10^7		
2	5.02×10^3		
3	5.23×10^5		
4	0		
5	0		
6	5.12×10^6		
7	3.24×10^4		
8	9.53×10^5		
9	7.4×10^6		
10	1.21×10^7		
11	0		
12	0		
13	3.63×10^7		
14	3.00×10^7		
15	5.92×10^6		
16	1.16×10^6		
17	7.50×10^7		
18	0		
19	0		
20	4.60×10^6		
21	1.45×10^4		
22	2.29×10^7		
23	7.71×10^6		
24	1.34×10^6		
25	1.74×10^7		
26	9.97×10^5		
27	1.50×10^6		
28	4.31×10^6		
29	1.16×10^6		
30	2.66×10^6		
31	8.38×10^6		

Table C-3.

DF-2a

LOCATION SENSITIVE PRIORITIZATION DATA
STATE INFORMATION

SOURCE DESCRIPTION Coal-Fired Steam Electric Utilities

AVERAGE PLANT SIZE _____ (TONS/YEAR)

NUMBER OF STATES _____

STATE CODE (XX)	STATE PRODUCTION (TONS/YEAR)	NUMBER OF PLANTS	REFERENCE
32	6.50×10^6		
33	2.22×10^7		
34	5.39×10^6		
35	4.86×10^7		
36	2.23×10^3		
37	0		
38	4.34×10^7		
39	0		
40	6.10×10^6		
41	4.01×10^5		
42	1.95×10^7		
43	5.28×10^6		
44	1.10×10^6		
45	3.35×10^4		
46	5.51×10^6		
47	4.17×10^6		
48	2.54×10^7		
49	1.13×10^7		
50	6.47×10^6		

APPENDIX D

EXAMPLE OF DETAILED CALCULATION

1. SOURCE INFORMATION

- Source Type: Acrylonitrile Manufacturing
- Input Data for all Plants

Total Capacity (CAP) = 530706 Mg
Frequency of operation (f) = 1.0
Number of emitted materials (N) = 10
Height of emissions (h) = 30.5 m

Material emitted	TLV, g/m^3	Emission factor, g/Mg	Emission height, m
Particulate		20.0	30.5
SO_x		26,000.0	"
NO_x		7,300.0	"
CO		178,500.0	"
Acrylonitrile	0.045	9,500.0	"
Acetonitrile	0.070	9,000.0	"
Hydrogen cyanide	0.011	1,300.0	"
Propylene	1.88	101,000.0	"
Propane	1.97	140,000.0	"
Lube oil	0.067	3,550.0	"

- Input Data for Plant 1

Plant capacity (CAP_1) = 81647 Mg/yr

County population density (P_1) = 1103 persons/km^2

2. IMPACT FACTOR CALCULATION

The emission rate for particulates (Q_1) is calculated as follows:

$$Q_1 = \left(\frac{1}{f}\right)(YPS)(CAP_1)(E_1)$$

$$= \left(\frac{1.0}{1.0}\right)(3.17 \times 10^{-8})(81647)(20)$$

$$Q_1 = 0.0518 \text{ g/sec}$$

$$\chi_{max_1} = \frac{(2)(0.0518)}{(38.43)(30.50)^2}$$

$$\chi_{max_1} = 2.9 \times 10^{-6} \text{ g/m}^3$$

Defining $A_1 = \left(\frac{\bar{\chi}_{11}}{F_1}\right)^2 \left(\frac{\chi'_{11}}{S_1}\right)$

The first plant is in Louisiana, and from Table A-2, $\chi' = 1.73 \times 10^{-4}$ g/m^3), and since $\chi'/S < 1.0$, we set this ratio $\chi'/S = 1.0$.

Then, $$A_1 = \left(\frac{2.92 \times 10^{-6}}{2.6 \times 10^{-4}}\right)^2 (1.0)$$

$$A_1 = 1.24 \times 10^{-4}$$

and for acrylonitrile:

Emission factor (E_5): 9500 g/Mg

TLV = 0.045 g/m^3

$$F_5 = 0.045 \left(\frac{40}{168}\right)\left(\frac{1}{100}\right)$$

$$F_5 = 1.07 \times 10^{-4} \text{ g/m}^3$$

$$Q_5 = \left(\frac{1.0}{1.0}\right)(3.17 \times 10^{-8})(81647)(9500)$$

$$Q_5 = 24.6 \text{ g/sec}$$

$$\chi_{max_5} = \frac{(2)(24.6)}{(38.43)(30.5)^2}$$

$$\chi_{max_5} = 1.38 \times 10^{-3} \text{ g/m}^3$$

Since S is undefined for acrylonitrile, we set:

$$\frac{\chi'}{S} = 1.0$$

and define $A_5 = \left(\frac{\bar{\chi}_{51}}{F_5}\right)^2 (1.0)$

$$A_5 = \left(\frac{1.38 \times 10^{-3}}{1.07 \times 10^{-4}}\right)^2 (1.0)$$

$$A_5 = 166.$$

This process is repeated for the ten emitted materials and the impact factor for the first plant is:

$$I_{x_1} = (1103)\ [1.94 \times 10^{-4} + \ldots + 166 + \ldots A_{10}]^{1/2}$$

$$I_{x_1} = (1103)[551]^{1/2}$$

$$I_{x_1} = 25,891$$

The data for the next plant capacity and county population density are then read and the process continues in the same fashion until all five impact factors are computed. The final impact factor is then:

$$I_x = I_{x_1} + I_{x_2} + \ldots\ldots + I_{x_5}$$

$$I_x = 25,891 + \ldots + I_{x_5}$$

$$I_x = 41,709$$

and after rounding

$$I_x = 40,000$$

Detailed input data used in this calculation are presented In Tables D-1 through D-5.

Table D-1.

I·F·3 DETAILED INPUT PRIORITIZATION DATA Log No. 1005

Uncertainty Level B

CATEGORY Organic

SOURCE DESCRIPTION Acrylonitrile

SCC 3-01-026-08

SOURCE IDENTIFICATION American Cyanamide, Fortier, La.

SOURCE CAPACITY 90,000 (TONS/YEAR)
(PRODUCTION, FUEL USAGE)

FREQUENCY OF OPERATION 1.0

NUMBER OF HAZARDOUS MATERIALS EMITTED 10

COUNTY POPULATION DENSITY 2857 (PERSONS/SQUARE MILE)

MATERIAL EMITTED	TLV (g/m^3)	EMISSION FACTOR (lbs/ton)	AVG. EMISSION HEIGHT(ft)	AMBIENT CONC. (g/m^3)	REFERENCE
PARTICULATE		0.04	100		
SOX		52.0	100		
NOX		14.6	100		
HC					
CO		357	100		
Acrylonitrile	0.045	19.0	100		
Acetonitrile	0.070	18.0	100		
Hydrogen Cyanide	0.011	2.6	100		
Propylene	1.88	202.	100		
Propane	1.97	280.	100		
Lube Oil	0.067	7.1	100		

Table D-2.

IF-3 DETAILED INPUT PRIORITIZATION DATA Log No. 1005

Uncertainty Level B

CATEGORY Organic

SOURCE DESCRIPTION Acrylonitrile

SCC 3-01-026-08

SOURCE IDENTIFICATION DuPont, Memphis, Tennessee

SOURCE CAPACITY 81,000 (TONS/YEAR)
(PRODUCTION, FUEL USAGE)

FREQUENCY OF OPERATION 1.0

NUMBER OF HAZARDOUS MATERIALS EMITTED 10

COUNTY POPULATION DENSITY 962 (PERSONS/SQUARE MILE)

MATERIAL EMITTED	TLV (g/m^3)	EMISSION FACTOR (lbs/ton)	AVG. EMISSION HEIGHT(ft)	AMBIENT CONC. (g/m^3)	REFERENCE
PARTICULATE					
SOX					
NOX					
HC					
CO					

Table D-3.

IPF-3

DETAILED INPUT PRIORITIZATION DATA

Log No. 1005

Uncertainty Level B

CATEGORY Organic

SOURCE DESCRIPTION Acrylonitrile

SCC 3-01-026-08

SOURCE IDENTIFICATION DuPont, Beaumont, Texas

SOURCE CAPACITY 90,000 (TONS/YEAR)
(PRODUCTION, FUEL USAGE)

FREQUENCY OF OPERATION 1.0

NUMBER OF HAZARDOUS MATERIALS EMITTED 10

COUNTY POPULATION DENSITY 255 (PERSONS/SQUARE MILE)

MATERIAL EMITTED	TLV (g/m^3)	EMISSION FACTOR (lbs/ton)	AVG. EMISSION HEIGHT(ft)	AMBIENT CONC. (g/m^3)	REFERENCE
PARTICULATE					
SOX					
NOX					
HC					
CO					

Table D-4.

PF-3

DETAILED INPUT PRIORITIZATION DATA

Log No. 1005

Uncertainty Level B

CATEGORY Organic

SOURCE DESCRIPTION Acrylonitrile

SCC 3-01-026-08

SOURCE IDENTIFICATION Monsanto, Chocolate Bayou, Texas

SOURCE CAPACITY 166,000 (TONS/YEAR)
(PRODUCTION, FUEL USAGE)

FREQUENCY OF OPERATION 1.0

NUMBER OF HAZARDOUS MATERIALS EMITTED 10

COUNTY POPULATION DENSITY 75 (PERSONS/SQUARE MILE)

MATERIAL EMITTED	TLV (g/m^3)	EMISSION FACTOR (lbs/ton)	AVG. EMISSION HEIGHT(ft)	AMBIENT CONC. (g/m^3)	REFERENCE
PARTICULATE					
SOX					
NOX					
HC					
CO					

Table D-5.

HF-3

DETAILED INPUT PRIORITIZATION DATA

Log No. 1005

Uncertainty Level B

CATEGORY Organic

SOURCE DESCRIPTION Acrylonitrile

SCC 3-01-026-08

SOURCE IDENTIFICATION Vistron, Lima, Ohio

SOURCE CAPACITY 158,000 (TONS/YEAR)
(PRODUCTION, FUEL USAGE)

FREQUENCY OF OPERATION 1.0

NUMBER OF HAZARDOUS MATERIALS EMITTED 10

COUNTY POPULATION DENSITY 270 (PERSONS/SQUARE MILE)

MATERIAL EMITTED	TLV (g/m^3)	EMISSION FACTOR (lbs/ton)	AVG. EMISSION HEIGHT(ft)	AMBIENT CONC. (g/m^3)	REFERENCE
PARTICULATE					
SOX					
NOX					
HC					
CO					

APPENDIX E

EXAMPLE OF OPEN SOURCES CALCULATION

1. APPROACH

In almost all cases, open sources were found to emit particulates. These emitted particulates vary widely in composition among the various source types. Thus, instead of substituting the primary standard for the potential hazard factor, a composite TLV was computed using the following:

$$TLV_c = \frac{1.0}{\sum_{i=1}^{N} \frac{f_{c_i}}{TLV_i}} \qquad \text{(E-1)}$$

where,

$$\sum_{i=1}^{N} f_{c_i} = 1.0$$

TLV_c = composite TLV, g/m^3

f_{c_i} = fraction of i^{th} component

TLV_i = threshold limit value of the i^{th} component, g/m^3

N = number of components

Since there is only one emitted material, the impact factor equation reduces to:

$$I_x = \sum_{j=1}^{K_x} P_j \left(\frac{\bar{\chi}_j}{F_j}\right)\sqrt{\frac{\chi'_j}{S_j}} \qquad \text{(E-2)}$$

where, S = particulate standard = 2.6×10^{-4} g/m^3.

For ground level releases (h=0), the Gaussian Plume equation reduces to:

$$\bar{\chi} = \frac{Q}{\pi\sigma_y\sigma_z u}$$

It is obvious that there is no maximum concentration for a ground level release. Two options were available to avoid this problem. The first method would be to select an average constant distance from source to receptor. In a relative rank ordering, this constant distance could be arbitrary since it would only affect the magnitudes of the impact factors and not their order. Another approach was to select an arbitrary imaginary height and use the χ_{max} equation. This latter approach was used to preserve computational compatibility with other source type calculations.

For open source location sensitive calculations, the production capacity on a single county or multi-county basis was known. For a given state, the population in the affected counties was summed and divided by the sum of the county areas in order to compute the population density of the $j^{\underline{th}}$ region.

As can be seen from the input data sheet (Table E-1), the sum of the state capacities does not equal the U.S. total

capacity. To preserve the confidentiality of individual manufacturers' production data, the Minerals Yearbook does not publish data for states with only a few individual manufacturers. These data are included in the national total as unreported capacity.

For these calculations, the last stage in computing I_x is as follows:

$$I_x = \frac{\text{Impact factor}}{(\text{Sum of reported quantity handled/total U.S. quantity})}$$

2. SOURCE INFORMATION

- Sample Type: Barite Milling

- Composite TLV (TLV_c)

Particulate consists of 92% Barite ($BaSO_4$) with a TLV of 0.5×10^{-3} g/m^3 and 8% inert dust with a TLV of 1.0×10^{-2} g/m^3. Therefore,

$$TLV_{composite} = \frac{1.0}{\frac{\text{inert fraction}}{TLV_{inert}} + \frac{BaSO_4 \text{ fraction}}{TLV_{BaSO_4}}}$$

$$TLV_c = \frac{1}{\frac{0.92}{0.5 \times 10^{-3}} + \frac{0.08}{1 \times 10^{-2}}}$$

$$TLV_c = 0.54 \times 10^{-3} \text{ g/m}^3$$

- Input Data:

  Total U.S. Capacity (CAP): 1,466,926 Mg/year
  Emission height (h): 3.05 m

Other data are presented in Table E-1.

Table E-1. PRIORITIZATION DATA (OPEN SOURCES)

SOURCE: Barite Milling FREQUENCY: 1.0
TOTAL U.S. QUANTITY: 1,466,926 UNITS: Megagrams
AVERAGE HEIGHT: 3.05 meters
DISTRIBUTION: POP_____ AREA_____ LOC ✓

Location	Quantity handled, Mg	Emission factor, g/Mg	Composite TLV, g/m^3	Population, people	Area, km^2
18	459,945	2,500	0.54×10^{-3}	585,787	531
25	210,468	"	"	15,015	1,968
43	181,438	"	"	2,093,840	8,972
28	174,181	"	"	2,630	14,558
4	154,222	"	"	21,498	1,608
Total	1,180,254				

3. IMPACT FACTOR CALCULATION

a. For State 18 (Louisiana)

Capacity (CAP_1) = 459,945 Mg/yr

Population density (P_1) = $\frac{(585787)(0.3858)}{205}$

= 1,102 persons/km^2

χ' for particulates = 1.73×10^{-4} g/m^3

$$\therefore \frac{\chi'}{S} = 1.0$$

Frequency of operation (f) = 1.0

Emission factor (E) = 2,500 g/Mg

and

$$Q_1 = \left(\frac{1.0}{f}\right)(E)(CAP_1)(YPS)$$

where YPS = 3.17×10^{-8} years/second

$$\therefore Q_1 = \left(\frac{1.0}{1.0}\right)(2500)(459945)(3.17 \times 10^{-8})$$

$$Q_1 = 36.5 \text{ g/sec}$$

$$\chi_{max} = \frac{(2)(36.5)}{(38.43)(3.05)^2}$$

$$\chi_{max} = 0.204 \text{ g/m}^3$$

and

$$I_{x_1} = P_1 \left(\frac{\chi_1}{F}\right)\left(\frac{\chi'_1}{S}\right)^{1/2}$$

where $F = (0.54 \times 10^{-3})(40/168)(1/100)$

$$F = 1.29 \times 10^{-6} \text{ g/m}^3$$

$$I_{x_1} = (1102)\left(\frac{0.204}{1.29 \times 10^{-6}}\right)(1.0)$$

$$I_{x_1} = 1.75 \times 10^8$$

b. For State 25 (Missouri)

$$\chi' = 2.06 \times 10^{-4} \text{ g/m}^3$$

$$\therefore \frac{\chi'}{S} = 1.0$$

$$CAP_2 = 210{,}468 \text{ Mg/year}$$

$$f = 1.0$$

$$E = 2500 \text{ g/Mg}$$

$$P_2 = 7.6 \text{ persons/km}^2$$

$$Q_2 = \left(\frac{1.0}{1.0}\right)(2500)(210468)(3.17 \times 10^{-8})$$

$$Q_2 = 16.68 \text{ g/sec}$$

$$\chi_{max_2} = \frac{(2)(16.68)}{(38.43)(9.3)}$$

$$\chi_{max_2} = 9.3 \times 10^{-2} \text{ g/m}^3$$

and

$$I_{x_2} = 7.6 \left(\frac{9.3 \times 10^{-2}}{1.29 \times 10^{-6}}\right)$$

$$I_{x_2} = 5.5 \times 10^5$$

c. For State 43 (Texas)

$$\chi' = 2.3 \times 10^{-4} \text{ g/m}^3$$

$$\therefore \frac{\chi'}{S} = 1.0$$

$$CAP_3 = 181{,}438 \text{ Mg/year}$$

$$f = 1.0$$

$$P_3 = 234 \text{ persons/km}^2$$

$$Q_3 = \left(\frac{1.0}{1.0}\right)(181438)(2500)(3.17 \times 10^{-8})$$

$$Q_3 = 14.4 \text{ g/sec}$$

$$\chi_{max_3} = \frac{28.8}{357.4}$$

$$\chi_{max_3} = 8.06 \times 10^{-2}$$

$$I_{x_3} = 234 \left(\frac{8.06 \times 10^{-2}}{1.29 \times 10^{-6}}\right)$$

$$I_{x_3} = 1.46 \times 10^{7}$$

d. For State 28 (Nevada)

$$CAP_4 = 174{,}181 \text{ Mg/yr}$$

$$P_4 = 0.18 \text{ persons/km}^2$$

$$\chi' = 3.74 \times 10^{-4}$$

$$\therefore \frac{\chi'}{S} = \frac{3.74 \times 10^{-4}}{2.60 \times 10^{-4}} = 1.054$$

$$Q_4 = (2500)(174181)(3.17 \times 10^{-8})$$

$$Q_4 = 13.8 \text{ g/sec}$$

$$\chi_{max_4} = 7.7 \times 10^{-2} \text{ g/m}^3$$

$$I_{x_4} = (P_4)\left(\frac{\chi_4}{F}\right)\left(\frac{\chi'_4}{S}\right)^{1/2}$$

$$I_{x_4} = (0.18)(5.97 \times 10^{4})(1.03)$$

$$I_{x_4} = 1.1 \times 10^{4}$$

e. For State 4 (Arkansas)

$$CAP_5 = 154{,}222 \text{ Mg/yr}$$

$$P_5 = 13.4 \text{ persons/km}^2$$

$$\chi' = 1.5 \times 10^{-4} \text{ g/m}^3$$

$$\therefore \frac{\chi'}{S} = 1.0$$

$$Q_5 = 12.2 \text{ g/sec}$$

$$\chi_{max_5} = 6.9 \times 10^{-2} \text{ g/m}^3$$

$$I_{x_5} = (13.4)(5.4 \times 10^4)(1.0)$$

$$I_{x_5} = 7.24 \times 10^5$$

$$I_x = I_{x_1} + \ldots + I_{x_5}$$

$$I_x = 1.91 \times 10^8$$

Since the reported totals are 80.5% of the U.S. total capacity,

$$I_x = \frac{1.91 \times 10^8}{0.805}$$

$$I_x = 2.37 \times 10^8$$

SECTION IV

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